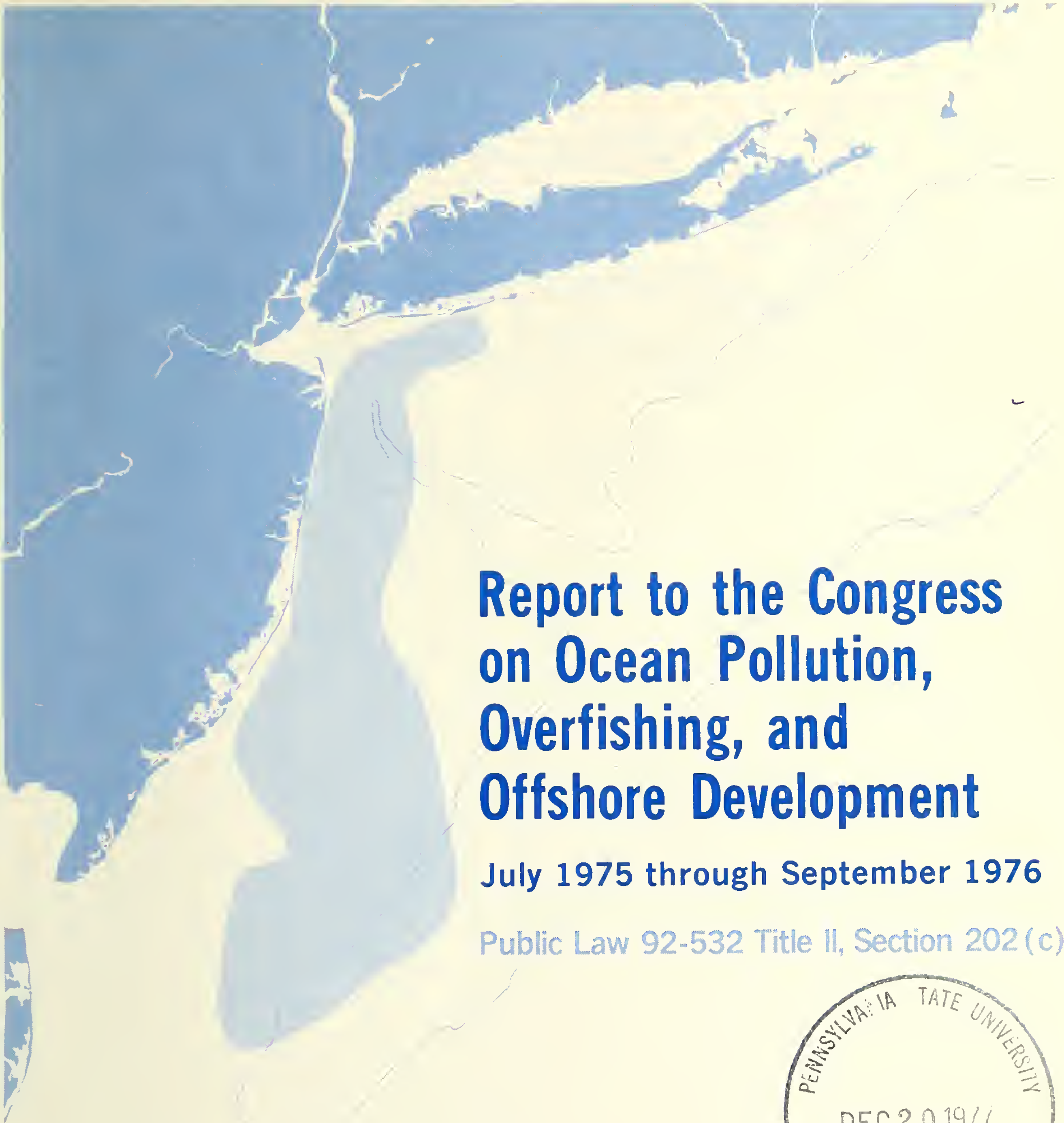

Report to the Congress on Ocean Pollution, Overfishing, and Offshore Development

July 1975 through September 1976

Public Law 92-532 Title II, Section 202 (c)

DEPARTMENT OF COMMERCE · UNITED STATES OF AMERICA

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
November 1977

Report to the Congress on Ocean Pollution, Overfishing, and Offshore Development July 1975 through September 1976

Submitted in compliance with Section 202 (c), Title II of the Marine Protection, Research, and Sanctuaries Act of 1972 (Public Law 92-532)

NOVEMBER 1977

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

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THE SECRETARY OF COMMERCE
Washington, D.C. 20230

NOV 14 1977

Dear Sirs:

I am pleased to submit to the Congress this fourth annual report on scientific research concerned with the impact of man's activities upon the oceans. The programs summarized in this report are representative of those conducted by the National Oceanic and Atmospheric Administration, in cooperation with other agencies and organizations, in response to the provisions of the Marine Protection, Research, and Sanctuaries Act of 1972, Title II, Section 202. As required by that legislation, the programs address existing and potential environmental problems related to ocean pollution, overfishing, and other ways in which man causes changes in ocean ecosystems. Research projects begun since the passage of the Act in 1972 are now yielding the information required to make more definitive evaluations of the potential effects of human activities of the natural environment.

Protection of the oceans is a vital national concern and the research that is carried out pursuant to the Marine Protection, Research, and Sanctuaries Act is an essential element in our efforts to insure rational use of the oceans and their resources. I am committed to the goal of achieving sufficient understanding of marine ecosystems so that we can accurately predict the effects of particular activities on the marine environment.

Sincerely,

Juanita M. Kreps

Juanita M. Kreps

President of the Senate
Speaker of the House of Representatives

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[The cover: Extent of the oxygen-depleted bottom waters off the New Jersey coast in the New York Bight in late summer 1976. See PART I.]

PART I

PROTECTING THE SEA

--- a summary of Parts II, III, and IV,
which describe U.S. Department of
Commerce, National Oceanic and Atmospheric
Administration research on ocean pollution,
overfishing, and offshore development --
July 1975 through September 1976

THE REPORT IN BRIEF

Major changes in governmental responses to the challenge of managing and protecting marine resources took place during fiscal year 1976; the necessity of active management of marine resources had become clear. Underscoring the urgency of marine environmental protection as an important part of management, Long Island ocean beaches had to be closed in late June when tons of floating trash, much of it looking suspiciously like sewage, washed up on them from the New York Bight.

In each area -- pollution, fisheries, and offshore oil development -- as well as others, research on long-range effects was conducted under Title II, Section 202 of the Marine Protection, Research, and Sanctuaries Act of 1972 (P.L. 92-532) to contribute to national efforts to meet the challenges. This report focuses on six major areas of this research conducted by the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce: studies of the New York Bight, investigations of the relationships of heavy metals and selected marine organisms, experiments on the effects of petroleum on marine animals, research on the status and effects of overfishing, work on the environmental questions raised by deep-ocean mining, and assessment of the environments of potential offshore oil lease areas. These are summarized in the following three sections of Part I and described in more detail in Parts II, III, and IV.

POLLUTION

NEW YORK BIGHT STUDIES

The value of doing the sort of research mandated by the Marine Protection Act was illustrated by events that occurred in the New York Bight. There, NOAA scientists were able to respond to two different environmental problems that arose in June 1976: the south shore Long Island beaches "floatables" incident, and the oxygen depletion problem (front cover) that all but wiped out bottom-dwelling sea life in a large area off New Jersey. Investigations of both problems benefited from the variety of basic and applied ocean research studies conducted by the New York Bight Project of NOAA's Marine Ecosystems Analysis Program (MESA).

Within the New York Bight -- the part of the Atlantic Ocean that lies just off Long Island and New Jersey -- the Bight Project is studying the natural biological, chemical, and physical subsystems that exist in an effort to describe their interrelationships with each other and with man-related stresses on the Bight ecosystem (fig. 1-1). An important part of the work involves identifying the many and varied sources of contaminant inputs to the Bight and attempting to describe their chemical and mineralogical composition. Particularly important is the development of an understanding of how these pollutants change as they mix and react with seawater in the Bight, and of their ultimate fate.

Basic data collected, and analyses performed in this project proved useful in mid-June 1976 when the south shore of Long Island was -- apparently unaccountably -- covered with floating trash washed ashore on each succeeding high tide. As the beaches were, one-by-one, closed to swimming by cautious public officials, there was speculation that the debris was the result of an explosion in a sewage plant that released about one million gallons of stored sludge into Rockaway Channel of Hempstead Bay on Long Island.

Based on past studies of the physical oceanography of the Bight, analysis of the washed-up materials (grease balls, garbage, charred wood, and bits of plastic and rubber), and weather data for June, Bight Project and Environmental Protection Agency (EPA) scientists were able to identify the Hudson River and Raritan River as the sources of most of the debris. The contribution of sewage, either from dumpsites offshore in the Bight or other sources, such as the sewage plant explosion was relatively minor compared to the flow of trash from the rivers and New York Harbor.

Near the end of June, as investigations of the "floatables" incident were well underway, reports began to arise of another, potentially serious, situation. A

FIGURE 1-1. THE NEW YORK BIGHT, AND SOME OF THE MAJOR CONTAMINANT SOURCES, SHOW UP CLEARLY IN THIS APRIL 7, 1973 IMAGE BY THE ERTS-I SATELLITE. SEE MAP IN PART II. (NATIONAL AERONAUTICS AND SPACE ADMINISTRATION)

commercial fishing trawler that had been operating about 15 km east of Long Branch, N.J., reported finding up to 75 percent dead fish in its nets -- mostly ocean pout, but including such other species as red hake, silver hake, and summer flounder. Subsequent reports from sport divers off the New Jersey coast confirmed that there had been an extensive kill of marine animals, especially bottom-dwellers such as crabs, lobsters, and surf clams. A later survey by the National Marine Fisheries Service (NMFS) resulted in an estimate that there had been a loss of about 100,000 metric tons of surf clams -- about 50 percent of the offshore surf clam stocks of New Jersey.

Sport divers found that although surface waters in the area were clear, water beneath the thermocline was very dark, with an accumulation of dark, stringy particles covering the bottom in a layer more than a centimeter thick. From those and other observations, and oceanographic data supplied by the MESA New York Bight Project (fig. 1-2), and the NMFS Northeast Fisheries Center, NOAA scientists concluded that natural factors were the primary cause of the problem. Specifically, it seemed that the decay of masses of dead phytoplankton (minute, floating plants) that had grown in profusion in surface waters earlier in the season and then sunk into the relatively still bottom waters, had used up most or all of the oxygen in the deeper layers.

Along with the NOAA National Environmental Satellite Service and National Aeronautics and Space Administration (NASA), the MESA/New York Bight Project is also participating in an evaluation of the potential benefits for both research and day-to-day monitoring of remote sensing in the Bight. In 1976, the Bight Project office contracted for analyses of selected data sets collected by NASA. The analyses are to emphasize surface circulation, and the distribution of chlorophyll-a and suspended particulates in the waters.

HEAVY METALS IN MARINE ANIMALS

It has been apparent for some time that "heavy metals" such as cadmium, mercury, and zinc can strongly affect marine animals. However, the nature of these effects; how they vary (if they do) with life stages, organisms, and the conditions of the marine environment; and what factors may be involved in altering the toxicity of the metals to the organisms have not been well known.

Since 1971, answers to these and other, related questions have been systematically sought at the NMFS laboratory in Milford, Conn. Experiments are expected to identify marine animals that are sensitive to heavy metals as well as those that may flourish in the presence of minute traces of the metals. Other work is concerned with the relationship of environmental fluctuations to the toxicity of the metals.

Studies in FY 76 used such species as the striped bass, flounder, lobster, American oyster, and bay scallops. Both the order and degree of metal toxicity were found to vary not only with such things as salinity, temperature, and the chemical form of the metal, but also the species and the life stage of the organism.

Much more tentatively, the Milford scientists have observed that early life stages generally seem to be more sensitive to mercury and silver than to cadmium. This may be due to the higher rate at which both juvenile and adult animals take up mercury and silver as opposed to cadmium. However, the order of toxicity in adult animals is the reverse of that seen in the young: cadmium appears much more toxic than mercury or silver -- perhaps because the adult animals acquire a tolerance to the latter two metals.

EFFECTS OF PETROLEUM ON MARINE ORGANISMS

A cooperative study between NOAA's National Marine Fisheries Service and its Environmental Research Laboratories (ERL) was set up to look into how crude oil and its various components may affect marine organisms. Some of the FY 76 financial support for this effort came from the Environmental Protection Agency and the Department of the Interior's Bureau of Land Management.

Of considerable importance to the maintenance of future stocks of fish and shellfish are the studies aimed at discerning any possible effects of petroleum on reproductive processes and juvenile forms. Species used in these efforts included rainbow trout (*Salmo gairdneri*), which are biologically related to saltwater fish, pink and coho salmon, and shrimp. Crude oil at the parts per thousand level in the diet of the trout apparently did not delay maturation of the fish; their eggs appeared as healthy as those from unexposed fish, and also developed normally.

However, when the salmon eggs were exposed to water-soluble components of crude oil (at a parts-per-million level) their hatching was delayed, and hatching success and subsequent growth seemed adversely affected. Sensitivity to this fraction of the oil increased with each stage in development from egg to juvenile fish. Studies with shrimp also found that various developmental stages have different sensitivities to the water-soluble fraction; the early stages are not necessarily the most sensitive.

Other studies have investigated acute effects of petroleum fractions such as naphthalene on various life stages of marine animals, including possible bioconcentration in their tissues. Spot shrimp at one developmental stage, for example, were found to accumulate 100 times the concentration of naphthalene in the water within 12 hours. Noting that scientific evidence from other laboratories suggests that metabolic products of aromatic hydrocarbons may be more damaging than the original compounds, NOAA scientists expanded their studies to include this possibility.

A major advance in the essential ability to detect accurately extremely low levels of petroleum compounds and their metabolites in the marine environment came with establishment of the NOAA/NMFS National Analytical Facility (NNAF). This was set up at the NMFS Northwest and Alaska Fisheries Center in Seattle in fiscal year 1976. It serves as the focal point within NOAA for analyses of trace chemicals in the marine environment, and for certification and standardization of analytical techniques.

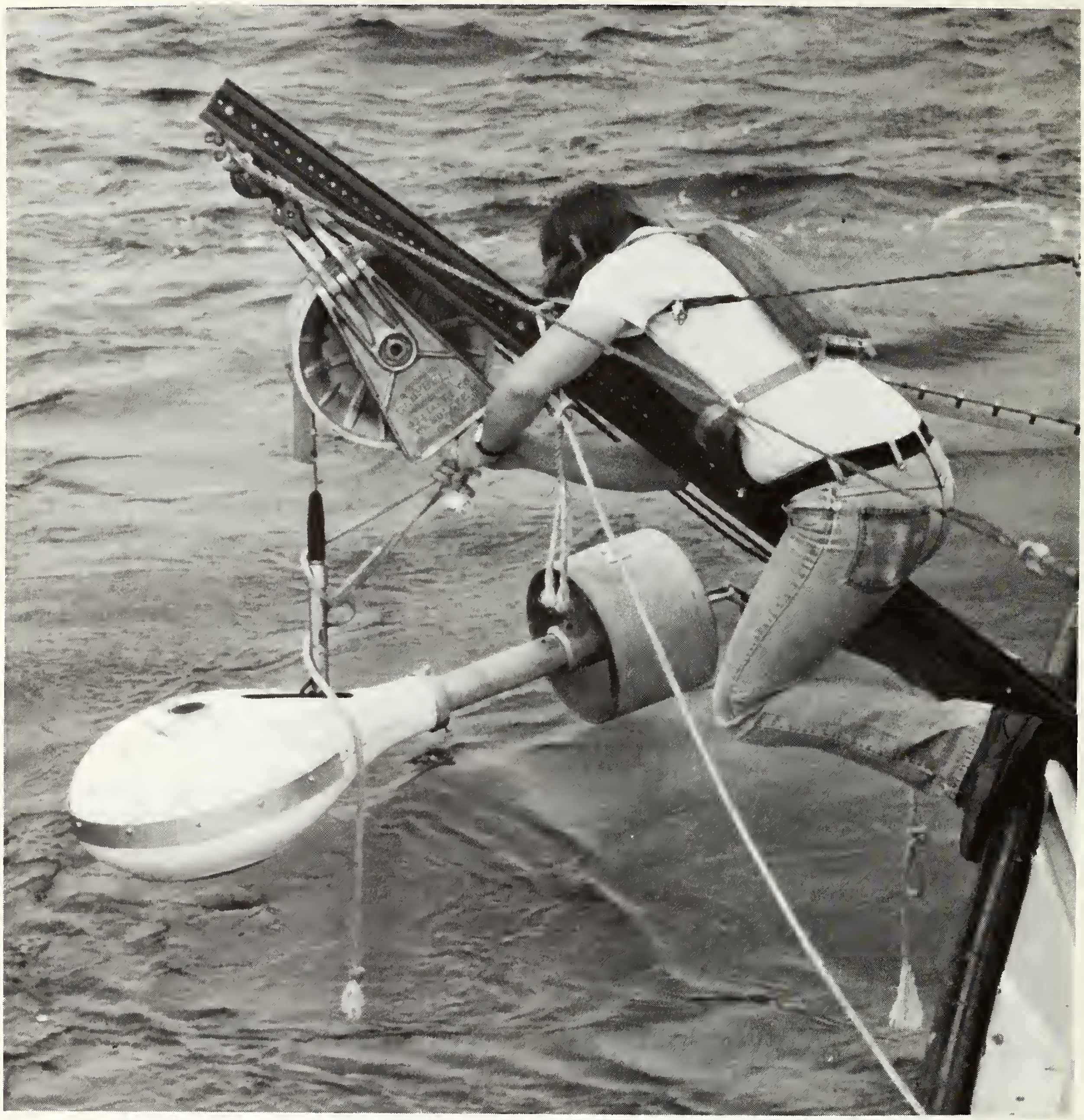

FIGURE 1-2. NOAA TECHNICIAN PREPARES TO LOWER AN ACOUSTIC SOUNDER TO DELINEATE BOTTOM FEATURES OF THE NEW YORK BIGHT. (NOAA PHOTO)

OVERFISHING

U.S. COASTAL WATERS

Overfishing continued to plague U.S. coastal fishery resources during fiscal year 1976, although, with passage of the Fishery Conservation and Management Act of 1976, hopes for an end to this problem rose considerably. The Act provides for U.S. management of nearly all fishery resources within 200 nautical miles of our shores. Foreign fleets -- the cause of much of the overfishing -- are to be allowed to continue fishing only with appropriate intergovernmental agreements and specific permits. The

Act, however, did not go into effect until March 1, 1977.

The status of overfishing in U.S. coastal waters of the Northwest Atlantic Ocean and East Bering Sea in FY 76 was about the same as reported in three previous annual summaries prepared for Congress by NMFS. (The FY 74 report also discussed fishery management under the International Commission for the Northwest Atlantic Fisheries, ICNAF.) Along the U.S. Pacific coast, Pacific barracuda, Pacific mackerel, and Pacific sardine were overfished by U.S. fishermen and are severely depleted. Stocks of arrow tooth flounder, hake, and Pacific ocean perch are depleted because of foreign fishing. Along the Southeast coast, Atlantic menhaden has been overfished by U.S. fishermen, but is not severely depleted and could recover rapidly with proper management. In the Gulf of Mexico, no major stocks were overfished in FY 76.

Whale conservation made some progress during FY 76 both at the annual meeting of the International Whaling Commission (IWC) and through special scientific meetings. For example, IWC's Scientific Committee concluded that to ensure the maximum sustainable yield (MSY -- the amount of fish or number of whales that can be taken in a year without reducing the stock's capacity to renew itself), the stock maintenance level for baleen whales should be at least 60 percent of initial stock size rather than 50 percent as had previously been estimated.

For the first time in the history of IWC, catch limits were set for all stocks of all species of whales commercially caught throughout the world, with but one exception. That exception was one stock of fin whales in the North Atlantic Ocean that were being taken by Spain, a nation that is not a member of IWC. North Atlantic sei and sperm whales were added to the list of regulated whales for the first time, as were minke whales in the North Pacific. The scientific committee recommended a zero quota on pelagic minke whales in the North Pacific until more data can be collected as to stock identities and sizes. Analysis of new catch data also led the Committee to recommend a reduction of 363 in the catch of Bryde's whales in the North Pacific (to a new total quota of 1,000).

Advent of the Fishery Conservation and Management Act brought the concept of optimum yield (OY), along with that of MSY, to public attention. OY is a broader concept than MSY, taking into account such factors as the economic and social well-being of commercial fishermen, recreational fishing interests, and general public welfare. It uses the concept of MSY as a base, but is aimed at providing the greatest overall benefit to the Nation, as well as preventing overfishing.

GULF OF ALASKA

Some of the most valuable fishery resources in the world are found in the Gulf of Alaska, a part of the North Pacific Ocean bounded on the west by the Alaska Peninsula, the north by the Alaska mainland, and the east by the Alaska panhandle. Recent annual catches from this vast area of the Pacific have been more than 300,000 metric tons, valued at more than $200 million. Of the total annual catch from the Gulf, nearly half is taken by U.S. fishermen.

The U.S. fisheries mainly seek such high-value species as crab, clams, salmon, and shrimp in near-shore waters and inlets. However, American fishermen also catch halibut, herring, sablefish, and small quantities of other bottomfish. Asian fishing fleets, mainly from Japan and the Soviet Union, but including a few boats from Taiwan and the Republic of Korea, seek mainly the rich bottomfish resources that lie offshore in deeper water.

Most Gulf of Alaska fishery resources were fully utilized in FY 76; a few, such as pollock and some flounder species, are underfished. Three important resources of the Gulf are now at low levels of abundance. Salmon, which is the most important in landings and value in the domestic fisheries, has been declining in abundance over the past 10 years. Overfishing in earlier years followed by poor survival conditions for young salmon may account for current low levels. The stocks of Pacific ocean perch, which had been a dominant element in the bottomfish community of the Gulf, were excessively fished in the mid-1960's by foreign trawl fisheries and have yet to show signs of recovery. Competition between the perch and pollock for a common food base and the intensity of the fisheries may be factors in the continued low abundance of Pacific ocean perch and the recent increase of pollock. Halibut stocks which are fished by United States and Canadian nationals have been declining in abundance since the 1960's, but as of 1975 this trend may have ended. Lessened survival of young fish because of poor environmental conditions, plus the sizeable bycatch of halibut in the foreign trawl fisheries, may be important factors in this decline.

All fisheries in the Gulf were under some control in FY 76. Quotas have been set on foreign fisheries for perch, sablefish, and other bottomfish. Closures to trawling of some ocean areas, and of halibut fishing in general during periods when the halibut may be particularly vulnerable, have been introduced. The North American halibut fishery has been strictly regulated by the International Pacific Halibut Commission. The State of Alaska regulates the domestic fisheries on crab, salmon, shrimp, and other species. Under the Fishery Conservation and Management Act, the North Pacific Fishery Management Council is expected to take further conservation measures.

OFFSHORE DEVELOPMENT

OCEAN MINING

Large areas of the deep-ocean floor are carpeted with manganese nodules -- a potentially valuable and stable source of cobalt, copper, manganese, and nickel. To date, U.S. industry has spent substantial sums in an effort to prepare for recovery of these nodules. NOAA's Office of Marine Minerals (of NOAA Headquarters) and the Environmental Research Laboratories' Marine Ecosystems Analysis (MESA) program joined forces in FY 76 to assess the potential environmental effects of mining these nodules in the open ocean beyond the limits of national jurisdiction.

Two projects were launched in FY 76: the two-phase Deep Ocean Mining Environmental Studies (DOMES) project for at-sea impacts, and a three-phase assessment of the effects of on-land processing facilities for the nodules.

DOMES-I is aimed at establishing environmental baselines at possible mining sites in the North Pacific Ocean, developing the ability to predict potential impacts of deep-ocean mining, and providing information for preliminary guidelines for industry and government. A draft progress report completed in August 1976 focused on the effects of a potential hydraulic mining system with two basic discharges, one near the sea floor and one at the surface.

Investigators found that changes in surface water temperature and in quantities of dissolved substances from the discharges would have only negligible effects on marine life in the potential mining areas. However, the large increases in suspended particulate matter in the sea near the mining ship's surface discharge would drastically reduce light penetration into the ocean. In turn, that would produce a large decrease in primary productivity (minute, floating plants -- phytoplankton -- that are at the base of oceanic food chains). This affected area is expected to be limited to a maximum of a few tens of kilometers from the ship.

At the bottom, passage of the nodule collection device, a sort of seabed vacuum cleaner, and formation of the deep-sea discharge plume (particulates) might kill all the bottom-dwelling fauna within the immediate mining area. Present knowledge of deep-sea biota is not adequate to permit estimation of the speed with which they might recolonize the mining area, but limited evidence available suggests that it would be exceedingly slow.

DOMES-II began in FY 77. It was designed (in FY 76) to monitor industry's at-sea tests of prototype deep-ocean mining systems to measure actual environmental effects, verify and refine mathematical models used in predicting those effects, and provide information on which to base any necessary modifications of environmental guidelines drafted during DOMES-I.

Environmental effects of onshore processing plants for manganese nodules could be equal to or greater than those for sea-based mining operations. Accordingly, a contract was signed in FY 76 for a study that will identify and describe the specific characteristics of onshore plants that are of greatest potential concern and that should be addressed in future work. This first phase of the three-phase assessment also is to consider the effects of performing all or part of the nodule-processing at sea. Later phases are to identify possible onshore plant locations and prepare impact studies for each.

ALASKA OCS ENVIRONMENTAL ASSESSMENT

One of the Nation's last great stores of petroleum and natural gas probably lies beneath the vast stretches of the Alaska outer continental shelf (OCS). Much of this area, however, has environmental hazards unlike those in other U.S. OCS areas, as well as a unique and delicate natural environment that might easily be damaged by offshore oil and gas extraction operations.

NOAA's Outer Continental Shelf Environmental Assessment Program (OCSEAP) is providing information about the natural environment and associated hazards in each of nine (as of FY 76) potential or actual lease areas off Alaska. The OCSEAP office is part of the Environmental Research Laboratories in Boulder, Colo. The work is being paid for through an interagency agreement with the Department of the Interior's Bureau of Land Management and involves staff from NOAA's National Marine Fisheries Service, National Ocean Survey, and Environmental Data Service, as well as liaison representatives from three other Federal agencies and the State of Alaska.

An unexpected discovery of a large-scale natural hydrocarbon seep in the Norton Sound region of the northern Bering Sea, about 40 km south of Nome, presented OCSEAP scientists with a unique opportunity. It will permit study of the effects of a natural hydrocarbon input to an otherwise pristine marine environment. A detailed chemical and biological study was to be set up to examine the effects of this seep in an environment covered by ice about eight months of the year. An intensive study will be made of the nearby waters, sediments, and living organisms to determine their inclusions, if any, of seep-derived hydrocarbons. If the seep proves to be of sufficient size, detailed studies of its effects on marine biota of the region are to be made.

In potential lease areas farther south -- Lower Cook Inlet, off Kodiak Island, and along the Aleutian Shelf -- OCSEAP researchers have noted the existence of severe hazards from earthquakes and a volcano, Mt. Augustine, which now shows signs of a lava buildup within its core, indicating that there may soon be an eruption. An area of apparently accumulating tectonic strain has been identified between the Shumagin Islands and Kodiak Island. This area has been seismically quiet since the 1938 Shumagin Islands earthquake, but seems likely to be the site, in the not-too-distant future, of a great earthquake (magnitude greater than 7.9 on the modified Mercalli scale), or series of major quakes, or both. Based on the history of earthquakes in the region, it seems most likely that this would occur between 1998 and 2025.

From the Norton Sound area, north through the Chukchi Sea and Beaufort Sea, ice presents real problems for offshore operations. Normally, polar ice in the region varies from about 4 m thick at the end of the winter to 1.8 m in summer, but pressure ridges may rise to 12 m or more and keels may form beneath the surface and be 18-to-30 m deep. These keels often scrape the bottom and make large gouges in the sediments.

Alaska also has one of the last large-scale, nearly pristine natural environments in the United States. Unique populations of whales, birds, and other creatures abound. In the northeast Gulf of Alaska, for example, the Copper River delta is the nesting ground for the entire world population of dusky Canada geese; ocean waters near Kodiak Island are among the most productive in the North Pacific, yielding hugh catches of dungeness crab, pollock, and shrimp and supporting a large population of maturing salmon; the world population of Steller sea lions is centered in the western Gulf of Alaska, as is the largest single concentration of harbor seals -- up to 10,000 animals in a single colony on Tugidak Island.

Bristol Bay, at the eastern side of the Bering Sea, is a particularly important area biologically. It is one of the most important salmon fishing grounds in the world. Some of the world's largest seabird rookeries are in the area, where the entire Pacific Ocean population of black brant gathers before fall migration, accompanied by hundreds of thousands of ducks, geese, and shorebirds. Baleen whales and killer whales are common, sea lions and seals dot the beaches and rocks, and several hundred bull walrus summer each year on the Walrus Islands. In spring and fall, Unimak Pass through the Aleutian chain is packed with thousands of birds flying through every hour.

PART II

THE WASTES OF CIVILIZATION

--- New York Bight studies

--- heavy metals in marine animals

--- effects of petroleum on marine organisms

One of the most heavily pressured areas of U.S. coastal waters is the New York Bight -- a 39,000 km^2 (15,000 mi^2) region of the Atlantic Ocean extending roughly from Cape May, N.J., to Montauk Point, N.Y., and seaward to the edge of the continental shelf with an average width of 165 km.

These waters daily receive the combined wastes of about 20 million people and a wide variety of industries, most of it via the estuaries of the Hudson and Raritan Rivers. Another major direct input of pollutants is the massive ocean dumping operation in the Bight -- the Nation's largest such operation. About 13 million cubic meters (460 million cubic feet) of sewage sludge, construction rubble, industrial wastes, and dredge spoil are deposited annually in four areas about 20 km east of Sandy Hook, N.J. (fig. 2-1).

Despite this heavy load of pollutants, the Bight continues to support such other uses as sport and commercial fishing, beach resorts and recreational areas, and wildlife sanctuaries. It is also a major world center of ocean shipping.

If the New York Bight is to continue to support this assortment of human activities, a clear understanding is needed of their impacts on the waters and the life in them, and on each other. Thus, the first project begun under NOAA's Marine Ecosystems Analysis (MESA) Program of the Environmental Research Laboratories in Boulder, Colo., was a thorough study of the occurrence, fate, and effects of the many potential pollutants entering the Bight. MESA was planned as an eight-year interdisciplinary effort, beginning when initial funding was received in January 1973.

Most MESA New York Bight Project studies have concentrated on a portion of the Bight bordering New York Harbor. This "Apex" area covers about 2,000 km^2 extending south along the New Jersey coast to latitude 40°10'N and east along the south shore of Long Island to longitude 73°30'W. Within this area, the two basic MESA objectives include: (1) investigating the fate and effects of pollutants and other man-related stresses on the ecosystem, and (2) identifying the important natural subsystems, processes, driving forces, stresses, and responses, and defining their interrelationships and rates of change.

In reporting on project activities for FY 76, it is difficult to clearly separate research on possible long-range effects of pollution from research on the more immediate effects of ocean dumping. In many cases, data collected and analyzed for one of these efforts have proved to be equally useful in the other. Two major events in the Bight in 1976 -- the "floatables" incident, and the oxygen depletion problem -- illustrate this interrelationship.

POLLUTED BEACHES--THE FLOATABLES INCIDENT

From June 14 to 21, 1976, south shore Long Island beaches were strewn with large amounts of floating trash and pollutants, apparently brought in from the waters of the Bight by persistent southerly winds. The material washed up on the more than 100 km of prime beaches included garbage, trash, charred wood, oil, plastics, rubber, and grease -- the last three normally associated with sewage. By the third week of June, local authorities had closed nearly all the south shore beaches, pending results of analysis of the material and cleanup of the beaches. Most beaches were open again by July 1, as the winds shifted and the incident ended.

No confirmation was found of early reports that raw sewage had washed up on the beaches, but analysis of tar and grease balls found among the litter showed extremely high fecal coliform (bacteria) counts. Thus, at least part of the "floatable" matter appears to have had a sewage origin. This discovery led, with the aid of a U.S. Coast Guard computer model for simulating drift of floating material (fig. 2-2), to an investigation of the possible sources of the floatables.

The major source of the floating material appears from this analysis -- a process of backtracking, based on knowledge of winds and surface currents in the area -- to have been the chronic release of sewage and other floatable wastes to the Hudson River/Raritan River estuarine system, which, in turn, discharges into the Bight. Other materials could have come from nearly anywhere in the Bight to the south and west -- even from as far as southern New Jersey, Delaware, and Maryland. One possible source that turned out not to be significant, however, was the sewage sludge dumpsite in the Bight. MESA scientists found that

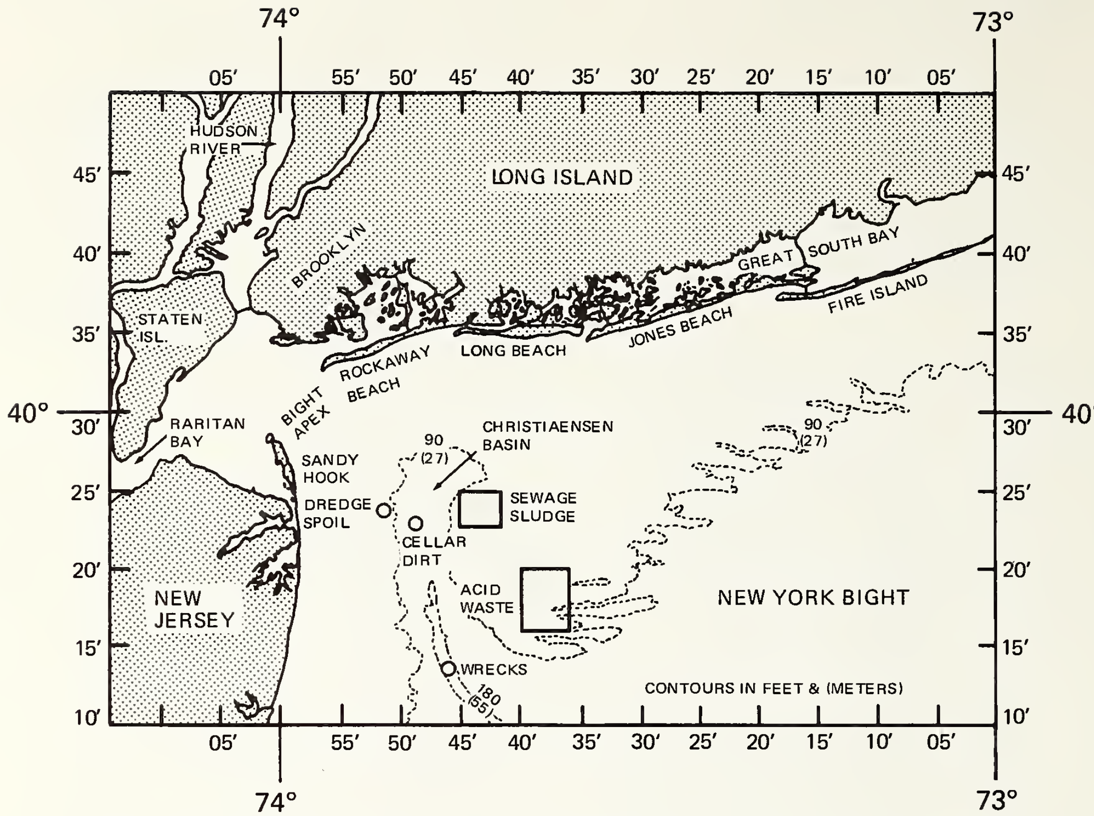

FIGURE 2-1. THE NEW YORK BIGHT APEX AREA, WITH MAJOR DUMP SITES.

contributions from this, and a sewage storage tank that exploded, releasing about one million gallons of sludge into Hempstead Bay, Long Island, were relatively minor. Only a maximum of 4 percent of the grease and oil, and 12 percent of the observed tampon applicators could have come from the sewage sludge dumpsite.

This was not the first incident of washup of floating pollutants on the New York Bight beaches, nor is it likely to be the last. In the short term, there is no technological solution to the problem -- if material is floating in the Bight, sooner or later some of it will be brought ashore. If the severity of these episodes is to be reduced, attention must be given to reducing the discharge of raw and partially treated sewage, and combined storm/sanitary sewer runoff. If the problem is to be solved, the overall quality of the waters of the Hudson River/Raritan River estuary will have to be drastically improved.

OXYGEN DEPLETION OFF NEW JERSEY

Beginning in late June, and running into October 1976, reports of extensive "fish kills" off the New Jersey coast indicated that a major environmental problem had arisen. Sport divers, commercial fishermen, and National Marine Fisheries Service (NMFS) scientists reported mass deaths of many shellfish and other bottom-dwelling organisms. The divers noted that below 12 m to 18 m (the approximate depth of the thermocline in early July) there was high turbidity in the water, consisting of a "brownish-yellow floc which settled and turned black, coating everything on the bottom." Sedentary forms such as surf clams, ocean quahogs, and sea scallops suffered the greatest mortalities. From surveys, scientists estimated that more than one half of the surf clam population off the New Jersey coast -- more than 100,000 metric tons -- had been destroyed by October. Ocean quahogs and sea scallops

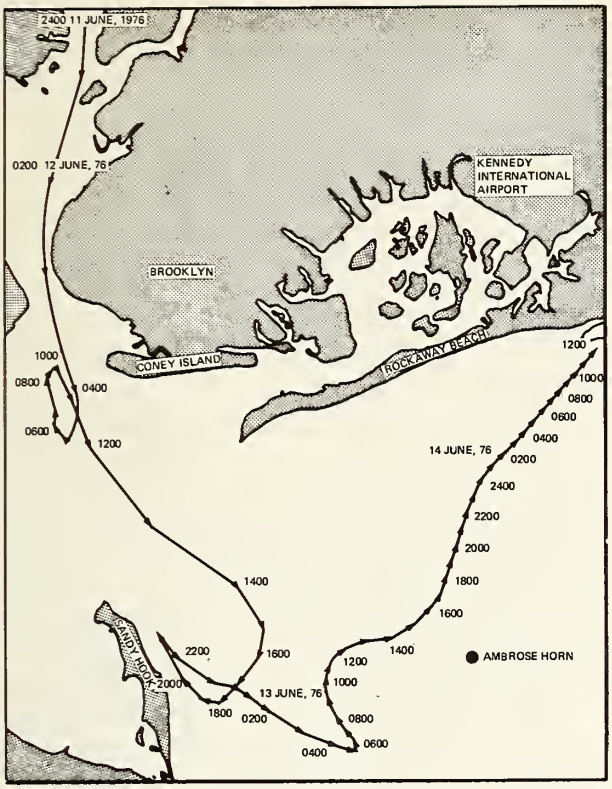

FIGURE 2-2. A COMPUTER-PREDICTED TRACK FOR MATERIAL ENTERING THE HUDSON RIVER FROM A FIRE ON THE 66TH STREET PIER AT 2400 EDT, JUNE 11, 1976 (U.S. COAST GUARD MODEL TEST CASE 2).

had significant but lesser mortalities. Lobster catches were reduced by almost 50 percent during the period (fig. 2-3).

The MESA New York Bight Project and NMFS Northeast Fisheries Center were given the responsibility of examining the causes and effects of this "fish kill." The direct causes proved to be anoxic and near-anoxic conditions in ocean bottom waters and associated generation of hydrogen sulfide. The Bight Project was able to contribute data and analyses from its ongoing program of studies to address the conditions, including material on:
1) water structure and physical/chemical properties; 2) surface and subsurface currents; 3) meteorological conditions and their interactions with Bight waters; and 4) how continental shelf bottom topography influences oceanic characteristics in the area.

For example, data from five cruises (December 1975, and April, May, June, and September 1976) were applicable to the study of the anoxia problem (fig. 2-4 and front cover). In-situ surface-to-bottom profiles of the water column from stations (fixed data-gathering sites) in the Bight showed water temperature, conductivity, transmissivity (of light), dissolved oxygen, and acidity/alkalinity (pH). Collected water samples yielded measurements of salinity, dissolved oxygen, nutrient content, trace metals, and other chemical characteristics. Data from the June cruise showed anoxic conditions in bottom waters in the area of the reported fish kills.

Tentative results of the studies indicate that natural factors (an algae bloom, in part) were the primary cause of the problem. First, the area over which the events occurred was too large to be affected significantly by a point source of pollutants such as the ocean dumpsites. Second, the inputs of oxygen-demanding materials (both directly and indirectly through

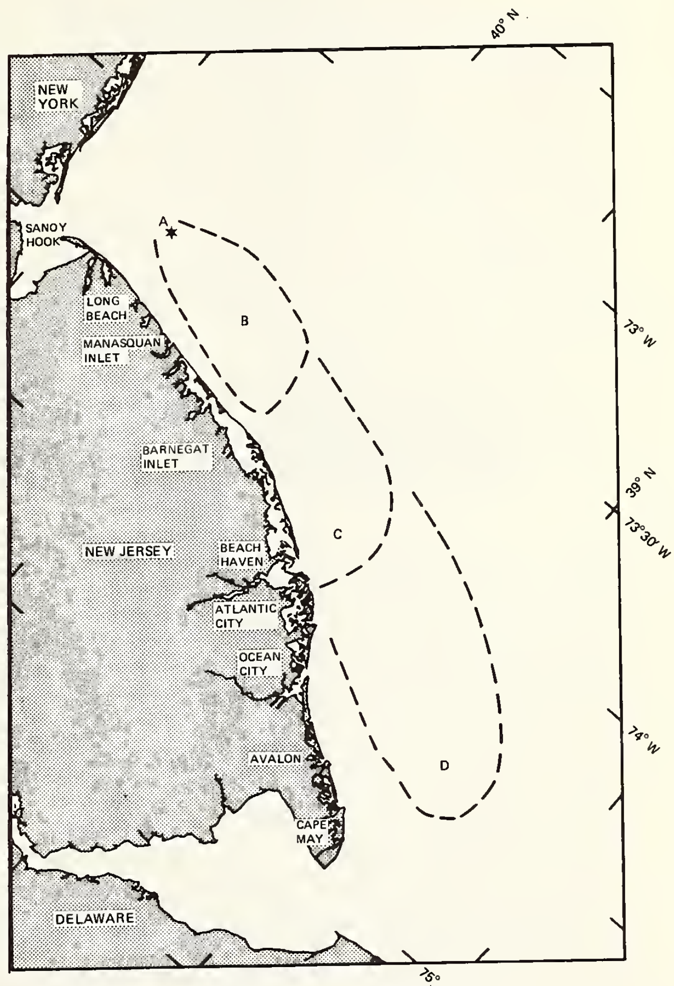

FIGURE 2-3. REPORTED MARINE ANIMAL DEATHS, JULY 2 - AUGUST 17, 1976; A = REPORT FROM COMMERCIAL TRAWLER JULY 2; B = EXTENT OF DEATHS BY JULY 9; C = EXTENT AS OF JULY 18; D = EXTENT BY MID-AUGUST.

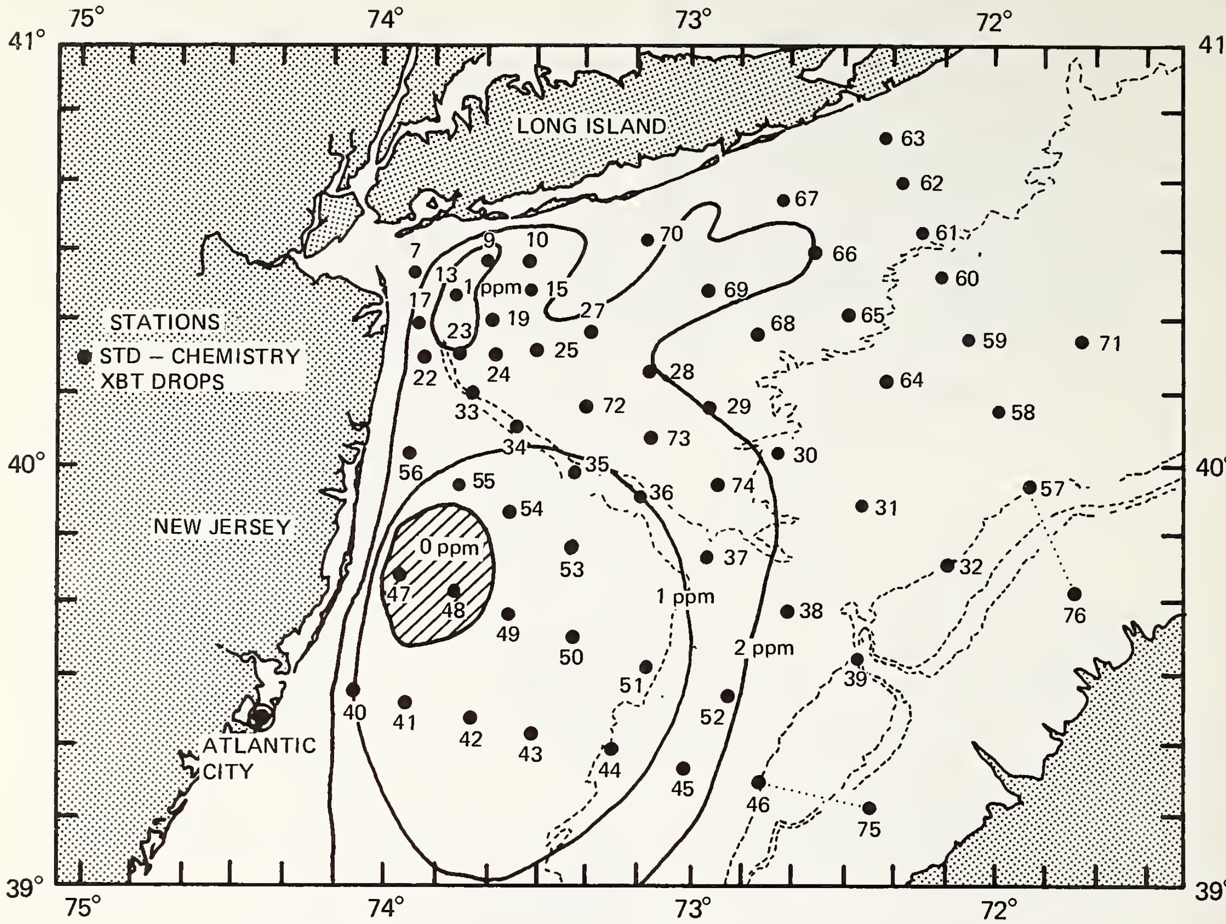

FIGURE 2-4. THE MESA NEW YORK BIGHT PROJECT EXTENDED WATER COLUMN CHARACTERIZATION GRID STATIONS, AND THE EXTENT OF OXYGEN-DEPLETED BOTTOM WATERS FOUND IN CRUISES BY THE NORTHEAST FISHERIES CENTER AT SANDY HOOK NJ, AND THE ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY IN MIAMI FL.

organism use of nutrients) from pollutant sources appear to be insufficient to generate such an episode, when compared to natural inputs (e.g., decay of dead algae in slow-moving bottom waters, which depleted the available oxygen supply). However, man-related inputs could have added to the severity of the problem. The extent of such an effect is being assessed, and a technical report presenting findings in detail will be published.

These mass mortalities of marine life in the New York Bight are of particular significance considering the heavy stress that man has placed on these coastal waters and the efforts to manage this marine resource more effectively. Man and his activities contribute large quantities of carbon and nutrients to the Bight, mostly through the Hudson/Raritan estuarine system. Certainly, adequate knowledge of the interactions of human activities and the natural systems in the Bight will depend on systematic and comprehensive analysis of all the data sets available and the translation of the results into information useful to those responsible for managing the quality of the coastal ocean.

RESEARCH FOR THE LONGER TERM

Work continued during FY 76 to develop a more precise understanding of the relative contributions of natural and man-related inputs to the New York Bight. Emphasis has been placed on the chemical and mineralogical composition of pollutant materials, and especially on their transformations as they initially mix and react with seawater when they are dispersed in the Bight.

Research also continues on the origin, extent, and composition of the low-density, high-carbon mud patches that occur seasonally offshore from Long Island. There is some evidence that the position of these patches may vary seasonally, but no evidence that they are steadily moving onto nearby beaches. There is no compelling evidence that these materials are principally derived from sewage sludge dumped into the Bight. Changes in the size and distribution of the mud patches are being examined using the techniques of continuous sidescan sonar recording, grab sampling for physical and chemical analyses, bottom photography, and direct measurement using diver-held graduated rods.

Studies of the organic properties of Bight sediments show that fecal steroids such as coprostanol and 24-β -- ethyl coprostanol can be used as tracers of sewage contamination. However, because of the large number of sources of raw and treated sewage in the New York Bight area, steroids cannot be used to identify any particular sewage-related source with its impact on the sediments or suspended matter.

The New York Bight Project is supporting research and development programs on remote surveillance and monitoring of the environment of the Bight as affected by pollutant sources. In April 1973 and 1975, two remote sensing experiments were conducted in the New York Bight by the NOAA National Environmental Satellite Service, with considerable NASA support. MESA participated in the planning of the 1975 experiment and provided logistics and field support. At the time, little analysis beyond initial data processing was performed. The experiments did, however, demonstrate that remote sensing had some value in coastal pollution studies.

In 1976, the New York Bight Project let several contracts for detailed analyses of select data sets from these experiments, augmenting analysis being made independently by NASA. MESA analyses emphasize surface circulation and the determination of chlorophyll-_a_ and suspended particulate distributions. Further, the various sensing systems and interpretive techniques used in the experiments are being evaluated. A complete description of the two experiments and an evaluation of the utility of remote sensing methods and data sets for various areas is in progress.

SELECTED PUBLICATIONS

In 1976, the American Society of Limnology and Oceanography published the proceedings of the symposium on "Middle Atlantic Continental Shelf and the New York Bight," which was sponsored by the MESA New York Bight Project, the New York Sea Grant Institute, and the Chesapeake Bay Institute of the Johns Hopkins University. The volume includes a summary of the results of studies of the New York Bight, made in conjunction with marine pollution problems. These studies provided the bases for recommendations of means to improve the quality of the New York Bight ecosystem. The symposium summary highlighted several research problems related to ocean pollution that have not yet been solved:

- Effects of dumping of dredged materials or sewage sludge into the Bight cannot easily be separated from the regional effects of wastes discharged in the estuarine outflows.

- It is still not possible to distinguish unambiguously the sources of waste products found in the Bight environment.

- Uncertainty about the possible movements and ultimate fate of waste materials reaching the Bight, due to the variability of natural and man-related events, still constitutes a problem for regulatory agencies at all levels of government in the region.

The MESA Technical Memorandum entitled "Contaminant Inputs to the New York Bight" was published in April 1976. The report presents an estimate of the location and magnitude of contaminant inputs into the New York Bight, indicates their relative importance, and identifies data gaps.

Additionally, six MESA New York Bight Atlas Monographs of a series of 30 technical monographs on the Bight were published in 1976. The series, which summarizes our present knowledge and identifies data gaps, is a cooperative effort of NOAA's MESA Program and the New York Sea Grant Institute.

HEAVY METALS IN MARINE ANIMALS

Studies have been underway since 1971 at the NOAA, National Marine Fisheries Service laboratory in Milford, Conn., to determine how heavy metals -- such as cadmium, copper, mercury, silver, and zinc -- affect the normal life functions of marine animals. These experiments, when correlated with contaminant levels in the environment, will identify the marine animals that are extremely sensitive to minute amounts of metals and also the animals or communities that are likely to flourish where traces of specific metal contaminants are present. Along with this, other work is aimed at determining to what extent natural environmental fluctuations, such as changes in salinity and temperature, may increase the toxicity of metals to marine animals, especially in their embryonic and larval stages.

The survival of embryos of the American oyster, Crassostrea virginica, when exposed to heavy metals singly, in combination, and in concert with various temperature and/or salinity regimes is also being studied.

Completed work has shown that salinity and temperature variations can increase the toxicity of mercury to juvenile bay scallops, Argopecten irradians. However, these scallop studies were limited to 96 hours duration; it is now necessary to determine what the interrelationships of metals and environmental variables would be for bay scallops over extended periods of time.

Other studies have been performed to determine the physiological and biochemical responses of marine animals such as the striped bass (Morone saxatilis), winter flounder (Pseudopleuronectes americanus), cunner (Tautogolabrus adspersus), and American lobster (Homarus americanus), when exposed to sublethal levels of cadmium, mercury, and silver for periods of two to five months. Changes in respiratory rate, blood ionic balance, and hematology, and changes in enzyme systems in various organs and tissues of these exposed animals have been examined.

The most obvious generalization that may be drawn from these studies is that both the order and degree of metal toxicity vary, not only with such parameters as chemical state, salinity, and temperature, but also with life stage and species. No other overall conclusion can be drawn at this point. A few emerging patterns, however, may be seen in the data thus far. For example, early life stages appear to be more sensitive to mercury and silver than to cadmium; this is true of the molluscs tested and of juvenile lobsters. Other marine larval forms also have been reported to have this same order of sensitivity.

Another consistent finding has been that mercury and silver are taken up very readily by tissues of both juvenile and adult animals, whereas cadmium is taken up to a far lesser degree. The difference in uptake rates may account, at least in part, for the relative toxicities of these three metals in the rapidly metabolizing early life forms. The greater the body burden of metal, it seems, the greater the toxicity. Paradoxically, the order of toxicity in adult animals is reversed from that in juveniles, with cadmium producing more severe effects than either mercury or silver, despite the much lower rate of cadmium uptake. The adult animals examined had apparently acquired a relative tolerance for mercury and silver that enabled their metabolisms to continue to function even with large body burdens of these metals.

Implications for recruitment to fish stocks should not be lightly dismissed. Heavy-metal pollution is greatest in our estuarine and inshore coastal waters, areas that are the breeding grounds and nurseries for many marine species important to both commercial and sport fisheries. Marine scientists have only begun to explore the effects of this class of pollutant. It is necessary now to proceed from these initial studies of individual metals to studies of antagonistic, additive, or synergistic effects, not only of various metal species in the presence of other metal species, but also of metals combined with other environmental challenges, whether issued by man or by nature. Worldwide concern with marine pollution and its effects underscores the urgency of understanding such multiple stresses.

EFFECTS OF PETROLEUM ON MARINE ORGANISMS

NOAA studies of the effects of petroleum on marine organisms are centered at the NMFS Northwest and Alaska Fisheries Center, with projects conducted in laboratories at Auke Bay, Alaska (near Juneau), and at Seattle, Wash. These studies are a cooperative effort between NOAA's NMFS and its Environmental Research Laboratories (ERL), involving the NMFS environmental investigations program, ERL's Marine Ecosystems Analysis Program (with partial funding from the Environmental Protection Agency), and the Outer Continental Shelf Environmental Assessment Program (with funding from the Department of the Interior's Bureau of Land Management).

REPRODUCTION AND LARVAE

One major concern is that petroleum may adversely affect reproductive processes or juvenile forms. These stages of the life cycles of fish and shellfish were investigated to determine whether potential problems exist. A major difficulty has been the maintenance of marine animals over an entire life cycle. Consequently, the fish used for the studies on reproduction were freshwater salmonids (Salmo gairdneri--rainbow trout), which are biologically related to saltwater salmonids. In fact, some trout (steelhead) are anadromous and spend part of their lives at sea.

The fish were fed a diet containing crude oil for several months before and during maturation. The concentration of petroleum in the diet was at the parts per thousand (ppt) level, a level much higher than those now encountered in the oceans. Maturation of the fish was not delayed, and mortalities of the eggs from exposed fish were no greater than for those from control fish raised on a petroleum-free diet (fig. 2-5). Moreover, the frequency of abnormalities was found to be similar for fish hatched from eggs from exposed and unexposed parents.

Other investigations were designed to determine how direct exposure to petroleum in the water column affects mortality and development of eggs. Eggs from pink salmon (Oncorhynchus gorbuscha) and coho salmon (O. kisutch) were exposed to the water-soluble fraction of petroleum at a concentration of a few parts per million. The eggs proved to be resistant to the water-soluble fraction in that they survived, but the time of emergence was delayed and both hatching success and growth appeared to be affected adversely. Sensitivity to the water-soluble fraction increased with each stage in development from egg to fry in seawater.

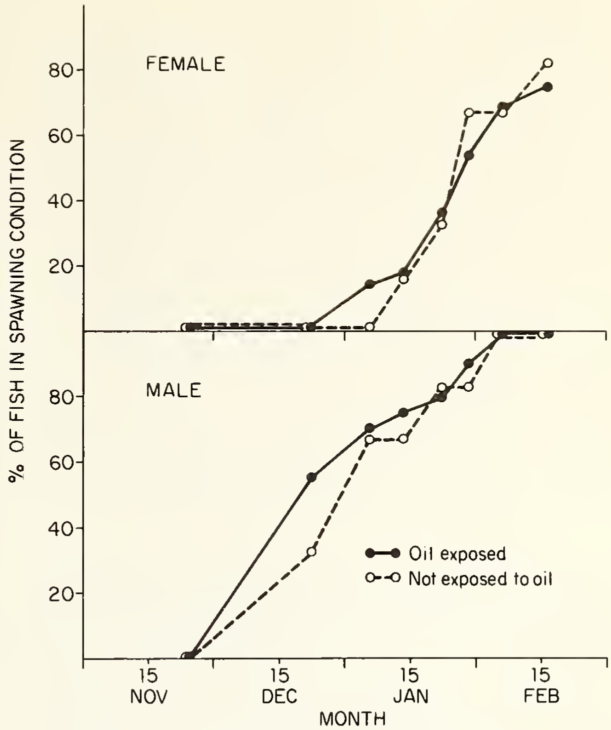

FIGURE 2-5. WHEN SALMONID FISH WERE FED EXTREME AMOUNTS (PARTS PER THOUSAND) OF PETROLEUM, THE EXPOSURE DID NOT AFFECT THE TIMING OF THE MATURATION OF THE FISH.

Shrimp (Eualus sp) that were bearing eggs were exposed for 30 days to a water-soluble fraction, and the subsequent survival of the larvae was monitored through the second stage of growth. The eggs apparently survive and hatch successfully after exposure to any chronic dose that the female can survive. In other studies, various stages of larval shrimp differed in their relative susceptibility, but the early stages were not necessarily the most sensitive. Larvae of most coonstripe shrimp (Pandalus hypsinotus) did not molt after exposure to less than one part per million (ppm) of the water-soluble fraction. Larvae that failed to molt eventually died.

Other studies have shown that both crude petroleum and the water-soluble fractions of petroleum are acutely toxic to several marine larval forms. However, a number of questions remain to be answered about the impact of petroleum on these life stages. These include the degree of toxicity of individual petroleum hydrocarbons to marine larvae, the degree of accumulation of petroleum hydrocarbons in larval tissues, the capability of early life stages of marine organisms to discharge accumulated hydrocarbons, and their capability to metabolically alter hydrocarbons. Answers were sought in studies using radioactively labeled naphthalene (a water-soluble component of crude and refined petroleum) and naphthalene complexed with bovine serum albumin. Exposure to concentrations of 8-to-12 parts per billion (ppb) naphthalene in flowing seawater resulted in 100 percent mortality within 24 to 36 hours for newly hatched Dungeness crab (Cancer magister) zoea and Stages I and V spot shrimp (P. platyceros). In each case, narcosis occurred several hours before death. No deaths were noted when larvae that had been exposed for 12 to 24 hours were subsequently moved to clean seawater.

In studies of the accumulation of naphthalene in Stage V spot shrimp, it was found that these organisms accumulated 100 times the concentration of naphthalene in surrounding seawater within 12 hours. When animals were transferred to clean seawater, they discharged most of the naphthalene in their bodies; however, metabolic products of the naphthalene were strongly resistant to discharge over a 24-hour period. We now have evidence that metabolites resist discharge for even longer periods. These results suggest that early developmental stages of marine crustaceans, such as shrimp and crabs, may be highly sensitive to the presence of certain petroleum-derived hydrocarbons in the marine environment.

ADULTS

Adults of most species appear to be less affected than the young. Scallops (Chlamys hericus) and hermit crabs showed delayed mortality following exposure to the water-soluble crude oil fraction. Thus, acute assays must be followed by observations to determine if the animals recover after exposure. The responses of marine animals after longer exposure periods to nonlethal levels must be known in order to evaluate the impact from many types of petroleum operations. Consequently, many of the studies in FY 76 were aimed at determining the physiological responses of marine animals to added petroleum.

BIOTRANSFORMATION

All animals have mechanisms to metabolize and excrete foreign compounds. These metabolic responses are not completely understood, but application to cold-blooded marine animals of knowledge available from studies with warm-blooded animals is important to determine the capabilities of marine organisms to adjust to the presence of petroleum hydrocarbons. Based on results at other laboratories using warm-blooded animals, a substantial body of evidence now exists to suggest that metabolic products of aromatic hydrocarbons may be more damaging than the hydrocarbons themselves. Accordingly, some studies of the accumulation of petroleum compounds were expanded to include studies of the formation and accumulation of metabolites. Radioactively-labeled aromatic hydrocarbons (anthracene, benzene, and naphthalene) were administered to coho salmon. The maximum concentrations of anthracene and naphthalene were found in the gall bladder; the maximum of benzene was in the liver. However, metabolites were also found in the brain, muscle, and residual carcass 72 to 144 hours after administration. Identification of metabolites and determination of whether they affect the viability of animals are two areas that need major emphasis.

OTHER STUDIES

The suggestion has often been made that petroleum may affect the chemosensory system of aquatic animals and change their normal behavior patterns in important activities such as finding food and mates, or avoiding predators. Some preliminary results of NOAA evaluations of the behavior patterns of both fish and shellfish indicate that short-term exposure to specific aromatic petroleum hydrocarbons did not mask the receptor sites that trigger the responses of shellfish to the presence of food. Benzene and naphthalene, however, did affect neural activity. These studies are being continued. Other behavior studies are being made of subjects such as the avoidance of petroleum; additional effects on the feeding responses of crabs, shrimp, and other intertidal animals; the burying response of clams; and respiration rates of salmon, shrimp, and crabs.

Animals in their natural environment are exposed simultaneously to multiple contaminants and other stresses, and possess mechanisms of adaptation. These natural factors and the mechanisms involved must be included in attempts to apply laboratory results and data to environmental conditions. Two aspects of this complex picture are being investigated: the effects of polychlorinated hydrocarbons (PCBs) on the reaction of fish to petroleum hydrocarbons, and the biological enzyme systems that transform both of these groups of contaminants and permit the animals to react or adapt to their presence. These systems are being studied both in experimentally exposed animals and in animals collected from study areas in Alaska waters and in Puget Sound, Wash.

The capability to detect accurately the extremely low levels of petroleum compounds and their metabolites in the marine environment is required in order to unravel and define pollutant effects on the resources. Thus, FY 76 saw the establishment of the NOAA/NMFS National Analytical Facility (NNAF) at the Northwest and Alaska Fisheries Center, Seattle, Wash. The facility is to provide support for NOAA's environmental programs in the analyses of trace chemical contaminants in the marine environment. NNAF also serves as the focal point within NOAA for the certification and standardization of analytical techniques, for cooperative analytical studies with various Federal, State, academic, and commercial institutions, and for authoritative information on the detection, identification, and assay of contaminants in the marine environment and biota.

A review of the present state of knowledge of the impact of oil pollution has been published in 1977 by Academic Press: Effects of Petroleum in Arctic and Subarctic Marine Environments and Organisms, Vol. I, "Nature and Fate of Petroleum" was issued in August; Vol. II, "Biological Effects of Petroleum: Alterations in Life Processes and in Community Structures" was issued in September.

PART III

OVERFISHING—A CHANGING WORLD

--- overfishing - a summary

--- Gulf of Alaska fisheries

OVERFISHING—A SUMMARY

The first report in this series included a review of overfishing and its long-term effects and a summary of the NOAA National Marine Fisheries Service (NMFS) MARMAP program of assessment of fishery resources near the United States for the period October 1972 - December 1973. The second report (for FY 74) reviewed progress in conserving those resources and discussed overfishing in the Northwest Atlantic. The third report (for FY 75) reviewed the status and management of U.S. marine fish stocks, and described the overfishing in the East Bering Sea. This report, for FY 76, summarizes overfishing, fishery yield concepts, the Fishery Conservation and Management Act of 1976, and the status of whale conservation, and discusses overfishing in the Gulf of Alaska.

In the Northwest Atlantic and the East Bering Sea, the situation remains essentially as reported earlier. In other areas, the following situations exist:

U.S. Pacific Coast - Stocks of Pacific barracuda, Pacific mackerel, and Pacific sardine have been overfished by U.S. fishermen and are depleted. Stocks of hake, arrow tooth flounder, and Pacific Ocean perch are depleted as a result of foreign fishing. These latter stocks will be under comprehensive management as a result of the Fishery Conservation and Management Act of 1976 and stand a reasonable chance of recovery, particularly since foreign fishing pressure has been reduced.

Southeast U.S. Coast - Atlantic menhaden has been overfished by U.S. fishermen, but is not severely depleted. With proper management the Atlantic coast stock could recover rapidly.

Gulf of Mexico - No major stocks are being overfished.

MAXIMUM SUSTAINABLE YIELD AND OPTIMUM YIELD

Marine fish stocks are a renewable natural resource that can provide a maximum sustainable yield (MSY): the largest average catch which can be taken continuously (annually) from a stock under current environmental conditions. For species with fluctuating recruitment (addition of new fish to the vulnerable population either through growth of smaller fish or migration from other areas), the maximum catch over the long run might be obtained by taking fewer fish in some years than in others. MSY is a traditional fishery biology concept that represents a best estimate of a safe upper catch limit that can be taken year after year without diminishing the stock's capacity for perpetual renewal.

A major change in fishing practices, such as a shift from taking large and old fish to small and young fish that have not spawned, could affect estimates of MSY. Similarly, changes in water temperature, salinity, ocean currents, and other environmental factors could affect stock productivity and, hence, potential yields. The history of research in the Northwest Atlantic, the Bering Sea, or areas along the northwest U.S. coast is too short to enable fishery biologists to predict important environmental changes, let alone the effects such changes would have on the productivity of the many species and stocks there. Thus, MSY estimates are estimates of potential yields that prevail now, and future changes in the environment or fishing practice could require new estimates. This is why it is important to continue to monitor the environment, the sport and commercial fisheries, and the biological status of the resources.

The concept of MSY, as a basis for determining recommended upper harvest levels for a given fish stock, has been expanded in the past decade to deal with the MSY of the integrated total finfish and shellfish biomass of large ocean areas such as the Northwest Atlantic Ocean. This broadened concept recognizes the reality of the numerous interactions within an ecosystem and the need to manage the entire stock assemblage. Management of the total biomass recognizes the problem of depleted stocks that may be secondary or incidental targets of fishing effort for more abundant stocks. For example, a zero quota for haddock or Pacific ocean perch is not necessarily sufficient to permit the species to restore itself, since certain other fisheries cannot help but take large incidental catches of these species.

The concept of optimum yield (OY) from fishery resources has been set forth by the Fishery Conservation and Management Act of 1976 (FCMA). This concept is broader than the consideration of fish stocks alone. It takes into account the economic and social well-being of commercial fishermen, recreational fishing interests, and general public welfare. OY should use the concept of MSY as a basis while allowing for other relevant economic and social inputs. According to the FCMA, optimum yield is the amount of fish to be caught that will provide the greatest overall benefit to the nation, particularly in reference to food production and recreational opportunities, while preventing overfishing.

THE FISHERY CONSERVATION AND MANAGEMENT ACT OF 1976

On April 13, 1976, President Gerald Ford signed into law an important piece of legislation concerning marine fishery resources: the Fishery Conservation and Management Act of 1976 (P.L. 94-265). It established, effective March 1, 1977, a fishery conservation zone (FCZ) off the coasts of the United States within which this country assumes exclusive management authority over all fish, except highly migratory species (tunas). In addition, beyond that zone, the Act provides for exclusive U.S. authority over all anadromous species spawning in U.S. waters and all U.S. continental shelf fishery resources. The inner boundary of the fishery conservation zone is the seaward boundary of each of the coastal States (territorial sea); the outer boundary of the zone is a line drawn so that each point on it is 200 nautical miles (nmi) from the baseline from which the territorial sea is measured (fig. 3-1).

A national program for the conservation and management of fishery resources within the FCZ is also provided in the Act, and is to be based on fishery management plans prepared by eight Regional Fisheries Management Councils. This program is specifically intended to prevent overfishing, to rebuild overfished stocks, to ensure conservation, and to realize the full potential of the Nation's fishery resources. Fishery Management Councils have been established for these areas: New England, the Mid-Atlantic, the South Atlantic, the Gulf of Mexico, the Caribbean, the Pacific (west coast), the North Pacific (Alaska), and the Western Pacific (Hawaii, Guam, and American Samoa). Each Council is required to prepare a management plan for each fishery within its geographical area based on seven national standards. The plans also must be approved by the Secretary of Commerce, who is charged with enforcing them. The national standards require that fishery management plans:

1) be designed to prevent overfishing and achieve the optimum yield of a stock of fish on a continuing basis

2) be based on the best scientific information available

3) where possible, manage individual stocks of fish throughout their entire range and manage interrelated stocks as a unit

4) be nondiscriminatory between residents of different States

5) promote efficiency in the use of fishery resources

6) take into account the variations among fisheries, fishery resources, and catches

7) minimize the costs of management and avoid unnecessary duplication of efforts

Until enforcement regulations are issued by the Secretary of Commerce, the plans are not binding upon the public. However, once the final regulations, which specifically set forth requirements necessary to carry out each management plan, are published in the Federal Register by the Secretary they have the full force and effect of law.

Except as otherwise provided under the Act, nations wishing to fish for living resources over which the United States exercises exclusive management authority or to aid or support one or more vessels at sea in the performance of any activity relating to fishing, must first conclude a governing international fishery agreement (GIFA) with the United States. This agreement must acknowledge the exclusive fishery management authority of the United States as set forth in the Act. The Act also specifies that only the portion of the optimum yield of a fishery subject to U.S. management authority which will not be harvested by vessels of the United States shall be allocated among foreign nations. Allocations are made by the Secretary of State, in cooperation with the Secretary of Commerce, taking into account such factors as traditional fishing, research contributions, and enforcement cooperation. Foreign nations that receive permission to fish within the fishery conservation zone must pay a fee to the United States based on the value of their allocation and the number and size of the vessels holding permits.

FIGURE 3-1. THE UNITED STATES 200-NAUTICAL-MILE FISHERY CONSERVATION ZONE

WHALE CONSERVATION

Additional gains were made toward the conservation of whales during FY 76 through special international scientific meetings and at the 1976 meeting of the International Whaling Commission (IWC). The new management procedure described in the FY 75 report was further refined and strengthened at the 1976 IWC meeting. The Scientific Committee concluded that the MSY stock maintenance level for baleen whales should be at least 60 percent of initial stock size rather than 50 percent as was previously estimated. In addition, further protection was accorded sei whale stocks in the Southern Hemisphere by removing a compromise of the sustained management stock concept that had been agreed upon in 1975.

As a result of detailed scientific analyses at the special meeting of the Scientific Committee on sperm whales in March 1976 in La Jolla, Calif., the catch limits on females were reduced by 83 percent, and those on males were reduced by 34 percent. Reevaluation of data on fin whales in Area I of the Southern Hemisphere resulted in the Scientific Committee recommendation that this stock be fully protected. Also, the committee recommendation for nine stock divisions for Southern Hemisphere sperm whales was adopted. This will mean that catches of sperm whales in each small division will be consistent with the Scientific Committee recommendations.

For the first time in the history of IWC, catch limits were set for all stocks of all species of whales commercially taken throughout the world with the exception of one stock of fin whales in the North Atlantic taken by Spain, a nonmember nation. At the 1976 meeting, sei and sperm whales in the North Atlantic were added for the first time, as was the minke whale in the North Pacific. In the North Pacific the Scientific Committee recommended that the catch limit for minke whales should be 541 on the western stock and zero on the pelagic stock until more data can be made available regarding stock identities and sizes. The committee also recommended a catch limit of 1,000 for currently taken stocks of Bryde's whales in the North Pacific, a reduction of 363 whales that was based on an analysis of new catch data.

Actions were also taken to attempt to regulate whaling by nonmember nations. It was agreed that catch limits should be set by stock area, according to the recommendations of the Scientific Committee, whether nonmember nations will catch whales in the area or not. Furthermore, for cases in which a stock is used by a nonmember country, IWC should send a resolution to the nonmember countries, naming them, stating the quota, and urging that measures be taken to avoid overcatching the stock concerned.

Further reductions were made by the commission in catch levels (quotas) resulting in an overall reduction by weight of around 50 percent, and overall reduction by number of nearly 40 percent over the levels of the past 4 years. This year's catch limits set by IWC (1976-77 season) call for a total of 8,741 Bryde's, male and female sperm, and minke whales in the North Pacific, a reduction of 922 over the 1975 catch limits; 15,554 sei, male and female sperm, and minke whales in the Southern Hemisphere, a reduction of 4,446 over the catch limits set in 1975; and 3,644 minke, fin, sei, and male and female sperm whales in the North Atlantic, an increase of 729 over the 1975 catch limits. The total catch limits for calendar year 1976 are 27,939 whales, a reduction of 4,639 over the limits established in 1975.

GULF OF ALASKA FISHERIES

The Gulf of Alaska (fig. 3-2) contains some of the most valuable fishery resources in the world. In recent years the annual catches from this region have been 300,000 to 400,000 metric tons (t) valued at more than $200 million (fig. 3-3). The U.S. fisheries are mainly in coastal waters and in the many bays and inlets that border the Gulf where such highly prized resources as clams, crabs, salmon, and shrimp are caught. U.S. nationals also fish halibut, herring, sablefish, and small amounts of other bottomfish. Of the total annual catches from the Gulf, almost 50 percent are taken by U.S. fishermen. The Asian fisheries, mainly those of Japan and the U.S.S.R. and, to a small extent, those of the Republic of Korea and Taiwan, target on the rich bottomfish resources that lie offshore in the deeper waters of the continental shelf and slope.

HISTORY OF THE FISHERIES

The oldest fisheries in the Gulf of Alaska are those of the native peoples who caught Pacific cod, halibut, herring, and other species for subsistence. Bottomfish and herring are still important sources of food to many groups of Alaskan natives, but

FIGURE 3-2. THE GULF OF ALASKA

these subsistence harvests are now dwarfed by commercial operations.

Commercial fishing in the Gulf of Alaska falls into two major periods. The first, from 1867 to the years immediately following World War II, was characterized by the development of the halibut, herring, and salmon fisheries of the Gulf by North American fishermen. The second period, from about 1950 to the present, saw a rapid rise in the production of U.S. fisheries for crab and shrimp and of foreign fisheries for bottomfish, king crab, shrimp, and whales. Commercial salmon fishing in Alaska began in the 1870's and expanded rapidly. By 1936, the annual catch from river systems emptying into the Gulf of Alaska had reached the all-time high of slightly over 260,000 t. Since then, the salmon catch has declined so that in most recent years (1974-75) the annual catches have been less than 45,000 t (fig. 3-4). But despite current low levels of abundance, salmon continue to be the mainstay of the U.S. fishery of the Gulf in terms of both landings and value. In 1974 landings of salmon were worth $54 million, about half the value of the year's total U.S. harvest from the Gulf.

Another important fishery that developed in the late 1800's is that for herring, a fishery that is almost entirely within the coastal waters and inlets of the Gulf. Since its inception, the herring fishery has been characterized by large fluctuations in annual landings because of varying market conditions, changes in uses of herring, and natural changes in abundance. Initially, the herring was used primarily for reduction to oil and meal, but later additional uses were found. The reduction fishery declined in 1921 because of market conditions, but then increased gradually after 1923, reaching its greatest production in 1937 when 114,000 t of herring were processed. By 1966, the reduction fishery had ceased to exist. Production of salted and pickled herring reached its peak in

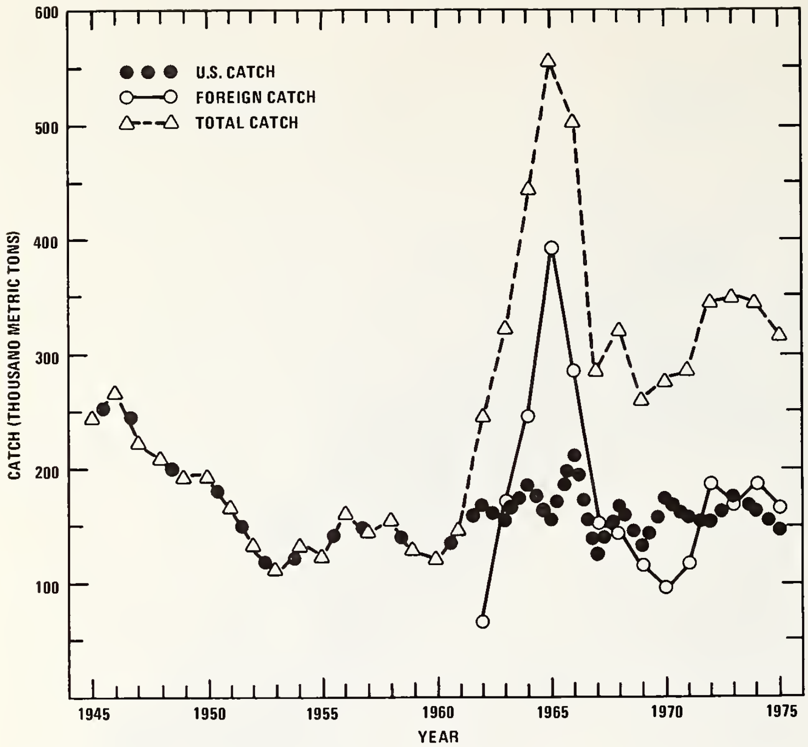

FIGURE 3-3. TOTAL UNITED STATES AND FOREIGN LANDINGS OF FISH AND SHELLFISH FROM THE GULF OF ALASKA SINCE 1945

1922, but poor market conditions led to the demise of this fishery in 1953. The herring fishery for bait coincided with the development of the halibut fishery, reaching a catch of 3,600 t in 1927; about 2,100 t of herring have been caught annually since the mid-1960's. In recent years, an increasing proportion of the total catch has been taken for roe, in demand on the Japanese market.

The commercial fishery for halibut began in the Gulf of Alaska after World War I. Both United States and Canadian nationals were involved in the fishery, and in 1924 the two nations ratified a halibut conservation treaty to regulate the fishery and to conduct research. The convention set up the International Fisheries Commission, later re-named the International Pacific Halibut Commission. Because of a combination of overfishing and environmental factors, the abundance of halibut declined and a new convention was signed in 1930 to broaden the Commission's regulatory powers. Under scientific management, the halibut stocks were gradually rebuilt, and in 1962 the landings from the Gulf of Alaska reached an all-time high of 24,000 t (fig. 3-4). High annual catches continued until 1966, followed by a decline, so that by 1974 only some 7,300 t were landed.

Other resources developed by U.S. fishermen during the period 1867-1950 were razor clams, cod, and sablefish. They have been of generally minor importance compared to crab, salmon, and shrimp. The first significant commercial landings from the Gulf came in 1867 when U.S. vessels began fishing for cod on banks off the Shumagin Islands. Since 1941, annual catches from this fishery have been erratic and relatively unimportant in the total landings from the Gulf. Razor clams are abundant in the intertidal region along the beaches of the central and western Gulf of Alaska. Peak production in 1917 exceeded 1,600 t. Annual catches since have fluctuated, reaching a new low in the last half of the 1960's because of resource depletion and habitat destruction from the 1964 earthquake. The catch is also limited by the State of Alaska requirement that clams be taken only from certified beaches because of the possibility of paralytic shellfish poisoning. Sablefish were relatively unimportant until about 1935; the peak catch of slightly more than 3,800 t was reached in 1945. Currently annual domestic catches are less than 900 t.

After 1950, the U.S. crab and shrimp fisheries developed rapidly. Three kinds of crab are caught: dungeness, king, and tanner. Dungeness crab occupy the shallow waters of protected bays and inlets. The peak catch level of 6,000 t was reached in 1968; catches have declined since then and were only 1,400 t in 1975. King crab

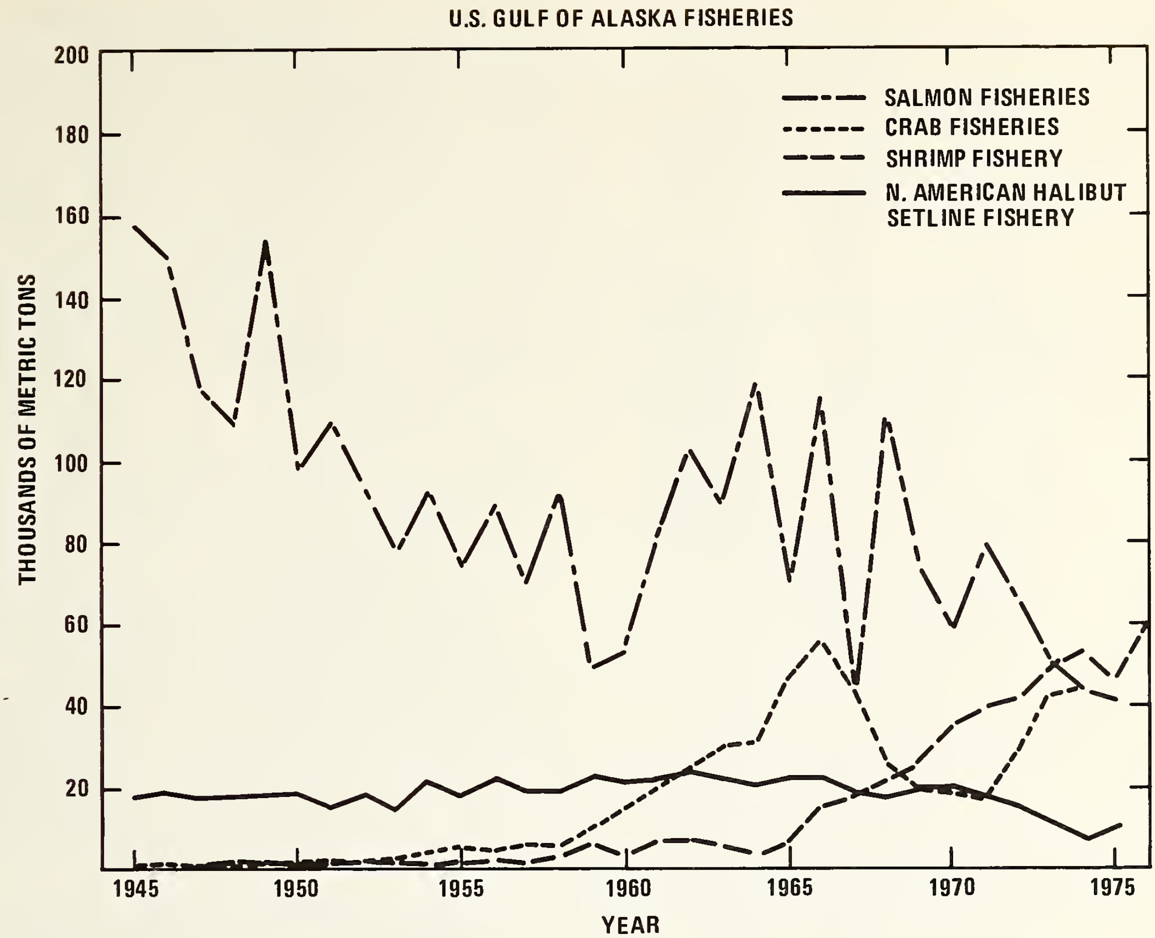

FIGURE 3-4. CATCH OF SALMON, CRABS, SHRIMP, AND HALIBUT IN THE GULF OF ALASKA SINCE 1945

fishing began in the 1920's; by 1966, 53,000 t were landed. In 1968, the catch dropped considerably and was less than 12,000 t annually for the years 1969-75, but catch levels have increased since then. Tanner crab production has increased rapidly, reaching some 5,900 t in 1970 and a peak of 27,600 t in 1973. Shrimp fishing began in 1915; by the period 1945-57, annual catches reached 400 to 1,400 t. In 1958 the demand for and price of shrimp increased because of low production elsewhere, and, as a result, the catch of shrimp from the Gulf of Alaska increased sharply that year to almost 3,600 t. Except for a slowdown in 1964 because of the Alaska earthquake, annual landings have continued to rise, reaching a level of 59,000 t in 1976.

A scallop fishery was developed by U.S. nationals in 1967 when scallop concentrations were discovered in offshore waters of the eastern Gulf of Alaska. Landings increased rapidly and by 1968 and 1969 peak catches of about 800 t were reached. By 1974, however, the catches had declined to about 450 t annually.

In the early 1960's, Asian fleets entered the Gulf of Alaska and began taking bottomfish, shellfish, and whales. The whaling was part of an overall operation by Japanese and Soviet fleets that included the waters of the Aleutian chain and the Bering Sea. By 1970, the total catch of whales from this general area of the North Pacific was almost twice that taken from

Antarctic seas. The modern pelagic whaling fleets could be rapidly deployed and, as a result, a successional fishery ensued in which one whale stock after another was overexploited. By 1965, the International Whaling Commission had placed whaling moratoriums on most major whale stocks (blue, fin, gray, humpback, and sei) in the North Pacific.

The trawl fisheries on Gulf of Alaska bottomfish began in 1962 when a Soviet fleet of 70 trawlers and support vessels began to target on Pacific ocean perch, an abundant bottomfish of the outer continental shelf and upper slope. The next year, a smaller number of Japanese fishing vessels entered the Gulf and began directed fisheries on Pacific ocean perch and sablefish. These operations expanded rapidly: the combined effort of the Soviet and Japanese fleets resulted in excessive annual catches of Pacific ocean perch ranging from 240,000 t to 380,000 t in 1964, 1965, and 1966 (fig. 3-5). Annual catch has declined since the peak year of 1965 to about 48,000 t in 1974. Asian trawl fisheries also have targeted on flounders, Atka mackerel, pollock, and sablefish. With the decline in abundance of the ocean perch, emphasis in the fisheries has shifted to pollock. Before 1972 the average annual catch of pollock by the foreign fleets was about 13,000 t. In 1972 and 1973 the catch jumped to 34,000 t and 37,000 t, respectively; in 1975 it reached 58,000 t.

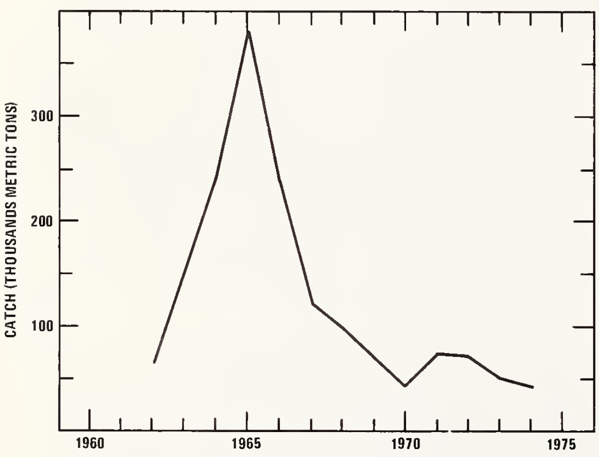

FIGURE 3-5. RISE AND DECLINE OF THE PACIFIC OCEAN PERCH FISHERY IN THE GULF OF ALASKA

Besides the trawl fisheries on bottomfish, the U.S.S.R. conducted a brief fishery on king crab in 1964 and 1965 in the western Gulf of Alaska, and there was a shrimp fishery by both Japan and the U.S.S.R. from 1964 to 1973. Since 1963, there has been an important Japanese longline fishery for sablefish. Yearly catches from this fishery rose rapidly in the late 1960's and peaked at about 30,000 t in 1972. In recent years, the average annual catch has been about 21,000 t. Republic of Korea longline vessels entered the Gulf of Alaska sablefish fishery in 1973, but their catch as of 1974 has been minor compared to that of the Japanese.

PRESENT CONDITION OF THE RESOURCES

The present condition of the Gulf of Alaska fishery resources is as follows:

Salmon. Five species of Pacific salmon (chum, coho, king, pink, and sockeye) are important in the fisheries of the Gulf. Pink salmon is the most abundant of the species and ranks first in salmon landings, followed by chum and sockeye. Current stock levels of salmon are depressed, and some important runs have become commercially extinct, such as the sockeye salmon of the Karluk River system on Kodiak Island.

One of the primary reasons for the long-term decline in salmon abundance has been overfishing, but natural and man-caused habitat destruction and poor survival conditions for the young fish have been important causative factors. For example, the 1964 earthquake resulted in a significant loss of intertidal spawning areas for chum and pink salmon in the Prince William Sound region. Some stocks such as pink salmon have improved in recent years. The catch of pink salmon increased sharply in 1975, and production since in some areas has been promising.

Halibut. A combination of factors may have brought about the decline of halibut that began in the 1960's. Catch limits during the period of peak production may have been set too high for the North American fishery. There was also a reduction of young fish being recruited to the fishery which became evident in the mid-1940's and was still continuing as of 1975. Intensive foreign bottom trawl fisheries have aggravated the decline in abundance of young halibut. These fisheries have been active since 1962 and take juvenile halibut incidental to their target species. Juvenile halibut are also captured incidentally in the large U.S. shrimp fishery. During the years 1963-67, when the catches of the foreign trawl fisheries peaked, the average annual incidental catch of halibut in these fisheries was estimated to have been 5,900 t. The average for more recent years (1970-74) has been estimated at about 3,300 t.

The condition of the halibut stocks of the Gulf of Alaska remains critical, and long-term prospects are uncertain. There is still no definite proof that the decline of the stocks has been arrested. The lowered catch limit set by the International Pacific Halibut Commission (IPHC) has reduced the mortality of adult halibut; increasing the minimum size at which halibut may be legally taken also has been beneficial. To reduce the incidental catch of halibut in the trawl fisheries, Japan and the U.S.S.R. have agreed to prohibit their vessels from operating in certain areas of the Gulf and at times when young halibut may be particularly vulnerable to capture by bottom trawls. The benefits of these area-time closures in improving young halibut survival may not be realized for several years. For Japan, time-area closures were begun in 1974 and continued in 1975 and 1976. The U.S.S.R. instituted closures in 1976.

Shrimp. U.S. shrimp vessels are currently catching all known major shrimp stocks of the region. Unfished stocks are generally considered to have relatively low commercial potential, and there appears to be little possibility of further expansion of the fishery. In a few fishing areas, stock levels have been declining but quotas were set by the State of Alaska to arrest this trend. In general, the shrimp stocks of the Gulf are in good condition and are being used fully.

Crabs. Crabs rank second only to salmon in both landings and value in the domestic fishery in the Gulf of Alaska. Three kinds of crabs are taken: king crab, tanner crab, and dungeness crab. All these resources are considered to be fully developed in both a geographic and fishery sense. The resources of both the king and tanner crabs appear to be in good condition with no indication of overfishing. Because of variable recruitment of young crabs to the fisheries, the take of king crab fluctuates from year to year.

Dungeness crab is of much less value to the crab fisheries than king and tanner crabs. Populations of dungeness crab are currently at low levels in most areas. The reasons for this decline are not fully known, but natural population fluctuations, overfishing, natural and manmade alterations of the habitat may be causative factors.

Clams and scallops. Clams and scallops are of relatively minor commercial importance: in 1974 they comprised less than 1 percent of the total landings from the Gulf. Razor clams are the most important clams in both the commercial and sport fisheries. Razor clam catches are at low levels because of overfishing, restrictions on the catch, and habitat disruption, although some improvement in resource condition has occurred in recent years. Scallop landings declined between 1970 and 1974, owing to overfishing of a limited resource and, to some extent, market conditions, area closures to protect commercial crabs, and the shift of scallop vessels into more lucrative fisheries, such as those for king and tanner crabs.

Bottomfish. Except for halibut and Pacific ocean perch, the condition of bottomfish stocks is considered to be good. Stocks of cod, flounders, and Atka mackerel have yet to reach full utilization. Pollock, which is considered to be the most abundant of the bottomfish, has been one of the main target species of the foreign trawl fisheries in recent years. In some areas, such as the offshore waters around Kodiak Island, the pollock fishery may be reaching maximum levels of allowable harvest, but for most other areas some expansion of the pollock harvest can be achieved with little danger of overfishing. There have been indications that pollock abundance has increased since the 1960's. The sablefish resource, harvested mainly by the Asian fisheries and to a smaller extent by United States nationals, is considered to be fully used. There are some indications that a decline in abundance may have begun in recent years.

Stocks of Pacific ocean perch were severely overfished in the mid-1960's and remain at low levels of abundance. Ocean perch is a long-lived and slow-growing species, and to realize the recovery of this resource may require low allowable catches for a period of 10 or more years.

Marine mammals. About 21 species of marine mammals live in the Gulf of Alaska. Those that have been subject to commercial harvest are the northern fur seal, sea otter, and eight species of whale (Bryde's, fin, gray, humpback, minke, right, and sei). Sea otters were nearly exterminated before the 20th century; they now are protected. Fur seals have been protected by formal international agreements since 1911, and their taking, on the Pribilof Islands of the Bering Sea, is strictly regulated. No pelagic fur sealing is permitted. From their nursery and breeding areas on the Pribilofs, fur seals migrate annually south to California waters. During their annual trek they pass through the Gulf of Alaska; adult males are believed to winter in the Gulf.

Several of the whale species (fin, gray, humpback, and sei) are at critically low levels of abundance, and the International Whaling Commission currently prohibits the hunting of these species for commercial purposes. Quotas have been established for sperm whales, seasonal visitors to the Gulf.

CONSEQUENCES OF OVERFISHING

Overfishing results in a perturbation in the ecosystem that is most difficult to assess. We know that a certain amount of fishing can be beneficial in that many of the older animals in the population being fished are removed, resulting in greater food availability to the younger ones and reduced cannibalism of the young by the older animals. The young animals then have a greater survival rate, mature earlier, and grow faster than in the unfished population. Overfishing, however, reduces even the numbers of young animals of the population, and a nearly-empty ecological niche develops that can become filled by ecologically similar species. These replacement species then become greater in abundance because of reduced competition for food and may even expand their geographical range. Replacement species may have more, less, or a similar value to the fisheries compared with the species they replaced.

In the offshore waters of the Gulf of Alaska, two major groups of animals have been severely reduced in abundance by the fisheries within a relatively short time period (less than 10 years) -- Pacific ocean perch and whales. What both these animals have in common is that they feed on animals that forage close to or on the primary source of food in the sea, the phytoplankton. Specifically, whales and perch feed largely on copepods, krill, and other animal plankton, and small midwater and near-surface dwelling fish. Following the reduction of the populations of whale and perch in the 1960's, there was evidence that pollock, an animal that also feeds at low trophic levels, had increased significantly in abundance in the 1970's. Pollock live at similar depths and in the same areas as Pacific ocean perch. Whether this association of perch decline with the subsequent increase in pollock abundance is a cause-and-effect relationship is not known at this time.

Another species whose abundance appears to have increased and that may have even extended its range is Atka mackerel, a semipelagic fish which also feeds on krill and other animals low on the food chain. The catch of Atka mackerel has increased in recent years, and these fish have become a target species in the Asian trawl fishery in some areas of the Gulf, particularly the offshore waters near Kodiak Island.

Consideration of these possible interactions between species populations like Atka mackerel, Pacific ocean perch, pollock, and whales shows that ecosystem studies in the Gulf may be helpful in determining harvest strategies for multispecies fisheries that would provide a balance in the catch levels of the various important species of this region.

For some of the fishery resources in the Gulf of Alaska, production is far below that which could be achieved if overfishing hadn't taken place. With salmon, for example, overfishing has not been the sole cause of the decline in numbers, but it has been an important one. Adverse natural environmental conditions and habitat disturbances are also factors. The overall effect, nonetheless, has been poor production of salmon in recent years resulting in lower monetary returns to fishermen and processors than could have been realized if judicious control and habitat maintenance had been introduced in earlier years. Potential production of salmon from the Gulf region could be at least 136,000 t and could be as high as 227,000 t. In contrast, during the 1930's and 1940's the annual production was often less than 91,000 t, and in the period 1973-75, it has been around 45,000 t.

For Pacific ocean perch, a high market value fish, the maximum sustainable annual yield from the Gulf of Alaska is estimated at 125,000 t. In just three years (1964-66) Asian fisheries removed more than 850,000 t and in recent years (1971-74) has averaged 63,000 t (fig. 3-5).

Recent exploratory fishing for Pacific ocean perch grounds by United States nationals in waters of southeastern Alaska has found very little perch. This area was once very productive for foreign vessels; its present low abundance of fish is symptomatic of all perch grounds in the Gulf. The once abundant perch stocks are now economically unusable. The U.S. market for Pacific ocean perch is strong, but the availability of the resource is too low in the Gulf region. As mentioned earlier, it may take 10-to-15 years of strict control to rebuild the stocks. A possible complicating factor is the presence of pollock, a species with similar food habits and distribution as the perch. Pollock have now increased and are the most abundant bottomfish in the Gulf, giving them an assumed competitive edge over perch that may prevent any recovery of the perch, regardless of fishing controls, unless pollock in turn become intensely fished. Pollock is a less valuable species than Pacific ocean perch in both the foreign and domestic fisheries.

ORGANIZATION FOR RESEARCH AND MANAGEMENT

Until the Fishery Conservation and Management Act of 1976 came into force in March 1977, the foreign fisheries of the northeastern Pacific, which includes the Gulf of Alaska, were regulated by a number of international conventions and agreements (table 3-1). In addition to establishing quotas, area and seasonal closures, size limitations, and regulations, these agreements included provisions for exchanging scientific information and fishery statistics among the participants. Except for halibut, U.S. fisheries for crab, salmon, shrimp, and other resources are managed by the State of Alaska. The North Pacific Fishery Management Council will exercise control over some offshore domestic fisheries in the Gulf. Foreign fisheries in FY 76 were managed through quotas and seasonal area closures as agreed in bilateral negotiations. The principal local, national, and international agencies involved with fishery research and management in the Gulf of Alaska in FY 76 were:

National Marine Fisheries Service (NMFS). The Service is involved with scientific research on and surveys of the Gulf of Alaska living marine resources. Its predecessor, the U.S. Bureau of Commercial Fisheries, was responsible for both research and management of domestic fisheries in the Gulf of Alaska before statehood in 1958. Currently, NMFS makes periodic surveys of bottomfish and shellfish resources to determine their extent and condition. Research is also directed toward herring, marine mammals, and salmon, and environmental studies are made in both inshore and offshore waters. Results are brought together in reports that describe the condition of specific resources and provide the basis for recommendations for resource use. These reports provide background information and guidelines for U.S. negotiators at fishery meetings with other nations and for the North Pacific Management Council.

NMFS is involved in cooperative studies with several other U.S. Government agencies, the State of Alaska, and foreign fishery agencies. In 1975, NMFS made an extensive survey of the bottom-living resources of the northeastern Gulf of Alaska for the Bureau of Land Management. This baseline study provided the Bureau with information for an environmental impact statement on the effects of large-scale oil development and production on the outer continental shelf. NMFS also cooperates with the State of Alaska by providing it with information on crab, salmon, and shrimp resources for use in regulating the U.S. fisheries. In cooperation with the fishery agencies of Japan and the U.S.S.R., NMFS observers board the fishing vessels of these nations to collect data on the bycatch and on the biology of target species.

State of Alaska. The State's Department of Fish and Game is responsible for research on and management of some of the inshore, domestic fisheries of the Gulf of Alaska region. The Department also collects statistics on the landings and operations of all Alaska fisheries.

North Pacific Fishery Management Council. The Council, one of eight established by the Fishery Conservation and Management Act of 1976, is responsible (as of 1 March 1977) for preparing plans for the conservation and management of fishery resources within the 200-nautical-mile-wide fishery conservation zone (FCZ) off Alaska also established by the Act. Off Alaska, the FCZ is technically 197 nmi wide: extending from the boundary of the three-nautical-mile-wide territorial sea to a point 200 nmi from the U.S. shoreline. The Council itself is composed of representatives from the Pacific coast States, and National and State government fishery agencies. A scientific and statistical committee will coordinate

TABLE 3-1. INTERNATIONAL AGREEMENTS CONCERNED WITH REGULATION OF FISHERIES IN EAST BERING SEA, THE ALEUTIAN ISLANDS, AND THE NORTHEAST PACIFIC OCEAN

Year, agreement, and nations involved	Arrangements	Remarks relating to the Gulf of Alaska
1911 North Pacific Fur Seal Convention Japan, Great Britain (for Canada), United States, and U.S.S.R.	Prohibited pelagic sealing. Countries without rookeries were compensated with skins taken by countries with rookeries. The agreement was renegotiated in 1957 with the parties agreeing to the promotion of research to determine and maintain the maximum sustainable production of the fur seal resources, but with due regard to the productivity of other living marine resources.	The taking of fur seals in the Gulf of Alaska is prohibited except for subsistence by Alaskan natives.
1924 Halibut Treaty Canada and United States	The Treaty established the International Pacific Halibut Commission to regulate the halibut fishery of the northeastern Pacific and East Bering Sea.	Regulatory measures (area-time closures and size of fish) are imposed on the Canadian and United States longline fishery for halibut in the Gulf of Alaska.
1946 International Whaling Convention Includes "North Pacific Rim" governments of Canada, Japan, United States, and U.S.S.R.	The Convention established the International Whaling Commission (IWC) to set up regulations to conserve whale stocks.	There is now a prohibition on whaling for most major whale stocks that forage in the Gulf of Alaska. The sperm whale is an exception, but a quota on this species is now in force.
1952 International Convention for the High Seas Fisheries of the North Pacific Ocean Canada, Japan, and United States	The Treaty established the International North Pacific Fisheries Commission (INPFC) to promote and coordinate scientific studies and recommend conservation measures to maintain levels of maximum sustainable productivity of fishery resources in the North Pacific and Bering Sea.	By this Convention all salmon and halibut east of longitude 175°W in the northeast Pacific are under abstention by Japan.
1967 United States-Japan Fisheries Agreement Japan and United States	Agreement concerned with the regulation of Japanese fisheries off the coast of the United States is periodically revised.	Latest revision in 1974 set new quotas and other regulatory measures for the Japanese fisheries concerned with rockfish, sablefish, and other groundfish of the Gulf of Alaska.
1967 United States-U.S.S.R. Fishery Agreement United States and U.S.S.R.	Agreement concerned with certain fishery problems in the northeastern Pacific and Bering Sea and is periodically revised.	Latest revision in 1975 sets new quotas and other regulatory measures on the U.S.S.R. fisheries concerned with rockfish, pollock, and other groundfish of the Gulf of Alaska.
1972 United States-Republic of Korea Agreement Republic of Korea (ROK) and United States	Agreement concerned with salmon and halibut of the North Pacific and Bering Sea.	By this agreement, ROK will abstain from fishing for salmon and halibut east of longitude 175°W.in the North Pacific and Bering Sea.
1975 United States-Poland Agreement Poland and United States	Poland agreed not to fish in Northeast Pacific for Pacific salmon, halibut, rockfish, black cod, flounders, soles, anchovy, Pacific mackerel, shrimp, and continental shelf fishery resources.	Certain area and times closures to protect halibut apply to Polish trawlers. Only four Polish trawlers allowed in the Gulf of Alaska at any one time.

research and assist the Council with the development of fishery management plans.

International North Pacific Fisheries Commission (INPFC). This commission brings together representatives of the governments of Canada, Japan, and the United States, "to promote and coordinate the scientific studies necessary to ascertain the conservation measures required to secure the maximum sustained productivity of fisheries of joint interest" and to make specific recommendations for the measures needed. A cornerstone of the convention that established this commission has been the principle of abstention, in which each pertinent government agrees to refrain from entering a fishery on stocks that already are fully used by one or more of the other convention parties, and that are under regulation to achieve maximum sustainable yield. In this way, salmon that spawn in North American streams have been afforded a fair degree of protection from overfishing. INPFC also serves as the principal scientific forum for deliberation on the condition of Gulf of Alaska fishery resources.

International Pacific Halibut Commission (IPHC). The Commission has been given the authority to recommend regulations to the member governments (Canada and the United States) on the North American setline fishery on halibut for optimum yields and to perform research to meet this end. IPHC makes annual surveys in the Gulf of Alaska to measure the strength of incoming year classes to the fisheries, and has tagging programs to study migrations and identify subpopulations.

Japan Fisheries Agency (JFA). The agency collects and collates catch and biological data from Japanese fisheries. Surveys of bottomfish are made by the Japanese government. Japanese scientists analyze fishery data and research findings, and present results at international fishery meetings.

U.S.S.R. Pacific Scientific Research Institute of Fisheries (TINRO). The principal fishery research agency of the U.S.S.R. in the North Pacific and Bering Sea is TINRO. It has the responsibility for research on the shellfish and finfish resources in this area. TINRO operates more than 30 vessels in support of its fishery mission.

EFFECTIVENESS OF RESEARCH AND REGULATION

Salmon. The salmon fisheries of Alaska are carefully regulated. The State of Alaska provides preliminary forecasts of the size of the runs each year and, as the fishing season progresses, readjustments are made to achieve full use of the salmon while allowing adequate escapement to sustain the next generation. Research is directed toward improving the habitat and providing accurate estimates of the various runs.

Pacific halibut. Although the North American setline fishery has been studied and regulated for 30 years, the halibut resource has declined in abundance over the past 15 years. Part of this decline is attributed to the incidental take of halibut by the large-scale and intensive foreign trawl fisheries. Season and area closures to the foreign trawl fisheries have reduced the catch of juvenile halibut, and, in conjunction with very restrictive measures on the fishery, are being pursued in an effort to arrest the decline.

Shrimp and crab (king and tanner). Management and research efforts by the State of Alaska have been effective in maintaining the stocks of shrimp, and king and tanner crabs in good condition. These resources are being fully used by the domestic fisheries.

Dungeness crab and razor clams. Although the levels of abundance of these resources are low, the State of Alaska has been in the process of rebuilding them through research and restrictions on the fisheries. Overfishing has been an important factor in the past, but habitat disturbance and adverse environmental conditions have been factors also, keeping population numbers low in recent years. The condition of the razor clam resource has improved somewhat.

Bottomfish. NMFS scientists gathered evidence in 1974-75 (status of stock reports) on the deteriorated condition of the Pacific ocean perch stocks and the potential danger of overfishing sablefish of the Gulf region. They recommended reductions in the catch of these resources by the Asian fisheries. The background information gathered and resulting recommendations were used effectively by U.S. negotiators at meetings with the principal nations fishing these resources. These nations agreed to set quotas on their fisheries which they hope will help rebuild the perch stocks and prevent the overfishing of sablefish.

PART IV

DEVELOPMENT IN THE MARINE ENVIRONMENT

--- preparing for deep-ocean mining

--- assessing Alaska OCS lease areas

OCEAN MINING

Assessment of the potential environmental effects of deep-ocean mining for manganese nodules was the major objective of a research program conducted by NOAA's Environmental Research Laboratories' (ERL) Marine Ecosystems Analysis program and NOAA's Marine Minerals Office during FY 76. Manganese nodules, which occur on the deep seabed beyond national jurisdiction, are a potentially valuable and stable source of copper, cobalt, manganese, and nickel. At present, this country depends on imports for all new cobalt and manganese, and for nearly all new nickel.

To date, U.S. industry has spent tens of millions of dollars to delineate commercial deposits, develop deep-ocean mining technology, and operate pilot processing plants. Work in these and other related areas is continuing. If legal barriers can be overcome and environmental concerns can be satisfied, commercial-scale operations could begin during the early 1980's.

During FY 76, NOAA launched two projects to assess the potential environmental effects of this proposed deep-ocean mining. The first of these, for which a $3 million appropriation was received during FY 76, was the two-phase Deep Ocean Mining Environmental Studies (DOMES) project, which is focused on potential at-sea impacts. The second is a three-phase project to assess the potential environmental and socioeconomic impacts associated with the on-land processing of manganese nodules.

NOAA first began addressing the potential at-sea environmental effects of deep-ocean mining in 1972 in meetings with other U.S. Government agencies and with industry, and by sponsoring research cruises. During FY 75, plans for the two-phase DOMES project were released and additional "pre-DOMES" research cruises were made.

DOMES I, the first phase of the at-sea project, began in FY 76 as a joint effort of an academic-government-industry research team; it is to conclude during FY 77. The objectives of DOMES I are to:

- establish environmental baselines at environmentally representative deep-ocean mining sites in the North Pacific Ocean area of commercial interest;
- develop first-order prediction capabilities for determining the potential environmental effects of deep-ocean mining; and
- provide information for the development of preliminary environmental guidelines for deep-ocean mining for use by industry and government.

Principal investigators and their staffs were selected in late FY 75 and early FY 76 from several universities and government agencies including NOAA's Pacific Marine Environmental Laboratory (Seattle) to form a multidisciplinary team for investigating baseline conditions and ranges of natural variability. Additional investigators were picked to review existing information on fishes and the smothering of deep-sea benthic communities by natural disasters. Proposals for a literature survey were reviewed, and one was selected for funding in April 1976. Planning and conduct of the DOMES project were reviewed periodically in FY 76 by the Deep Ocean Mining Environmental Study Advisory Panel.

Integrated investigations of the upper water column were made from the NOAA ship Oceanographer from August to September 1975 and again from February to March 1976. Studies concentrated on phytoplankton and primary productivity, variations in the zooplankton, nutrient chemistry, suspended particulates, and water movements. From March to May 1976, field work aimed at the lower water column, examining water chemistry, suspended particulates, and zooplankton. Bottom arrays emplaced by the National Science Foundation's program for the International Decade of Ocean Exploration (IDOE) manganese nodule project were recovered. From July to September 1976, the ship returned to the area for near-bottom circulation studies and benthic organism sampling using baited traps.

A draft progress report on Phase I was completed in August 1976 (fig. 4-1). It focuses on the effects of a potential hydraulic mining system with two basic discharges -- one near the sea floor and one at the sea surface.

DOMES investigators found that the depth of the surface water layers in the study area varied from 20 m to 120 m. A strong, stable pycnocline (the layer of water at the depth at which ocean density increases rapidly with increasing depth) was found at the base of the surface mixed layer -- a major environmental factor to consider in

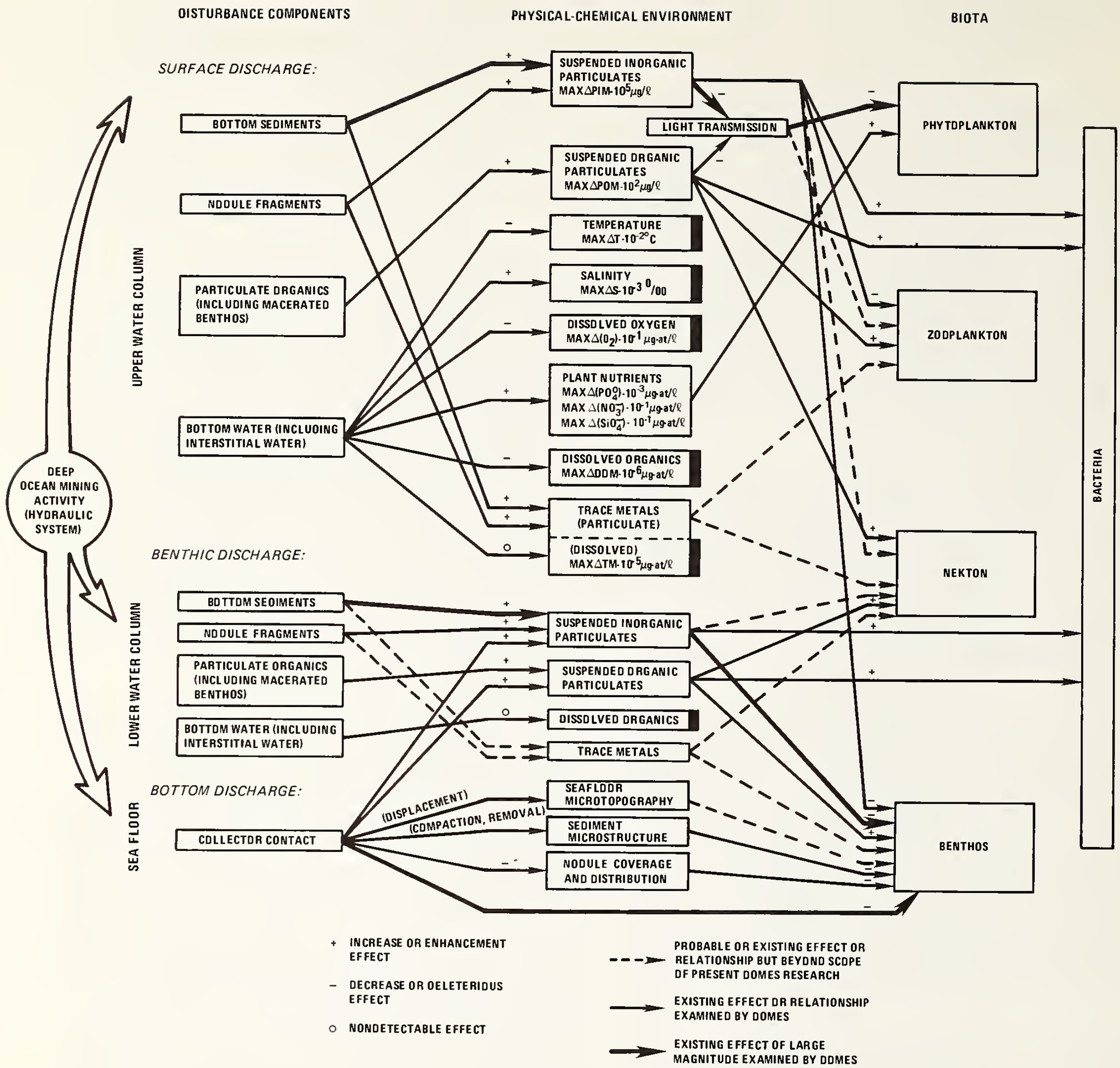

FIGURE 4-1. DOMES PRELIMINARY SUMMARY FINDINGS: DIRECT EFFECTS OF DEEP OCEAN MINING ON THE PHYSICAL-CHEMICAL ENVIRONMENT: AND THE RELATIONSHIPS OF CHANGES IN THE ENVIRONMENT TO THE MARINE BIOTA. MINING WILL HAVE SUCH A SMALL EFFECT ON SOME PARTS OF THE PHYSICAL-CHEMICAL ENVIRONMENT (SHOWN BY A BAR ON THE RIGHT-HAND SIDE OF THE BOX) THAT SUBSEQUENT EFFECTS ON THE BIOTA PROBABLY WILL BE NEGLIGIBLE.

evaluating the impact of marine mining. Among other findings were unexpected eastward currents at depths of 200 m and 300 m with large changes in current speeds over time; universally low natural nutrient content in the surface waters, but a sharp increase in nutrients with increasing depth; near-saturation (maximum) oxygen concentration in the surface layer; very clear waters; and relatively uniform benthic animal communities.

It appeared that changes in temperature and dissolved substances from mining activities would have only negligible impact on the biota living in the surface waters. However, initial results of the investigations suggest that suspended particulate matter released by the mining ships may have a detectable impact on the biota. Light penetration into the upper water column will be drastically reduced in the area near the mining ship's surface discharge, which may result in a large decrease in primary productivity. This area is expected to be limited to a maximum of a few tens of kilometers from the ship.

Activities of the biota are expected to have some effect on the fate of the discharge. The ingestion of suspended particulates, with their subsequent incorporation into fecal pellets, would in effect accelerate the sinking velocities of the sediment by orders of magnitude. This seems likely to be an important mechanism in removing sediments from the upper waters. In the benthic zone, mining will have very marked impacts both on the sea floor itself and on the overlying 20 m to 50 m of water into which the benthic effluent is released.

The direct effects could be complete mortality of the benthic fauna within the immediate mining area caused by the passage of the collection device and the resultant formation of a benthic discharge plume. Removal of nodules will also eliminate some of the habitat of some organisms. The present state of knowledge of deep-sea biota is not adequate to allow prediction of the rates of recolonization other than to note that reestablishment of the community is expected to be exceedingly slow. Sediments within the benthic discharge plume are expected to settle rapidly, yet impacts may be noted on the nepheloid layer and on the oxygen demand of the overlying waters. Actively swimming organisms will be attracted to the disturbance.

DOMES II, the second phase, has begun in FY 77. During DOMES II, industry's at-sea tests of prototype deep-ocean mining systems are to be monitored in order to observe and measure the actual environmental effects of deep-ocean mining systems, verify and refine as necessary models for the prediction of environmental effects, and modify as necessary the environmental guidelines drafted in the DOMES I project.

Processing plants used to recover metals from manganese nodules could have environmental effects equal to or greater than those of the sea-based deep-ocean mining activities. Phase I of a three-phase study of these potential effects began in FY 76 with the award of a contract to identify and describe the specific characteristics of manganese nodule processing plants that should be addressed in subsequent environmental and socioeconomic studies. In addition to providing quantitative information on such things as material, power, water, land, and personnel requirements, the work will provide chemical and physical descriptions of reagents, process chemicals, and wastes. Phase I is also considering the effects of performing all or part of the nodule processing at sea.

In the second phase, planned to start during FY 77, criteria will be identified for determining representative geographical areas in which processing and associated facilities might be located.

In addition, the Marine Board of the National Research Council's Assembly of Engineering was asked to assess marine hard mineral technology needs, including the methodology of environmental assessment. The study was started in FY 76 and is to conclude during FY 77.

In March 1976, a NOAA-sponsored Marine Minerals Workshop was convened to address, among other issues, the problems associated with environmental assessments in marine mining. A large number of recommendations resulted for both deep-ocean mining and the recovery of nearshore minerals. The workshop also focused attention on means to end the virtual moratorium that exists in the development of marine hard mineral resources in both State and Federal waters. In some areas, the development of sand, gravel, and phosphorite sources from these waters could reduce cost pressures created by the need to push further inland for supplies.

ALASKA OUTER CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT PROGRAM

INTRODUCTION

The Outer Continental Shelf Environmental Assessment Program (OCSEAP) of the National Oceanic and Atmospheric Administration (NOAA) is aimed at coordination of all Alaska marine environmental assessment activities relating to energy development. Begun in 1974, OCSEAP is managed by NOAA under an interagency agreement with the Department of the Interior's Bureau of Land Management (BLM), which provides most of the funding.

Investigations are managed by the OCSEAP Office in the NOAA Environmental Research Laboratories, Boulder, Colo., in conjunction with Alaska Project Offices in Juneau and Fairbanks. NOAA staff members from the National Marine Fisheries Service, National Ocean Survey, and Environmental Data Service; as well as representatives from the U.S. Fish and Wildlife Service and U.S. Geological Survey of the Department of the Interior; the Environmental Protection Agency; and the State of Alaska are liaison members of the program office staff.

The Alaska outer continental shelf (fig. 4-2) probably holds the Nation's last great store of petroleum and natural gas as well as some of the most valuable and controversial renewable marine resources. To protect these resources during lease operations and development, and to provide a base of information from which critical hazards can be predicted and possibly averted, OCSEAP is providing data for use by BLM in the preparation of environmental impact statements, selection of leasing sites, and monitoring of the impacts of oil and gas development. Data collected fall into six major categories: contaminant baselines, sources, hazards, transport, receptors (biota -- marine mammals, birds, fish, plankton, etc.), and effects. Data

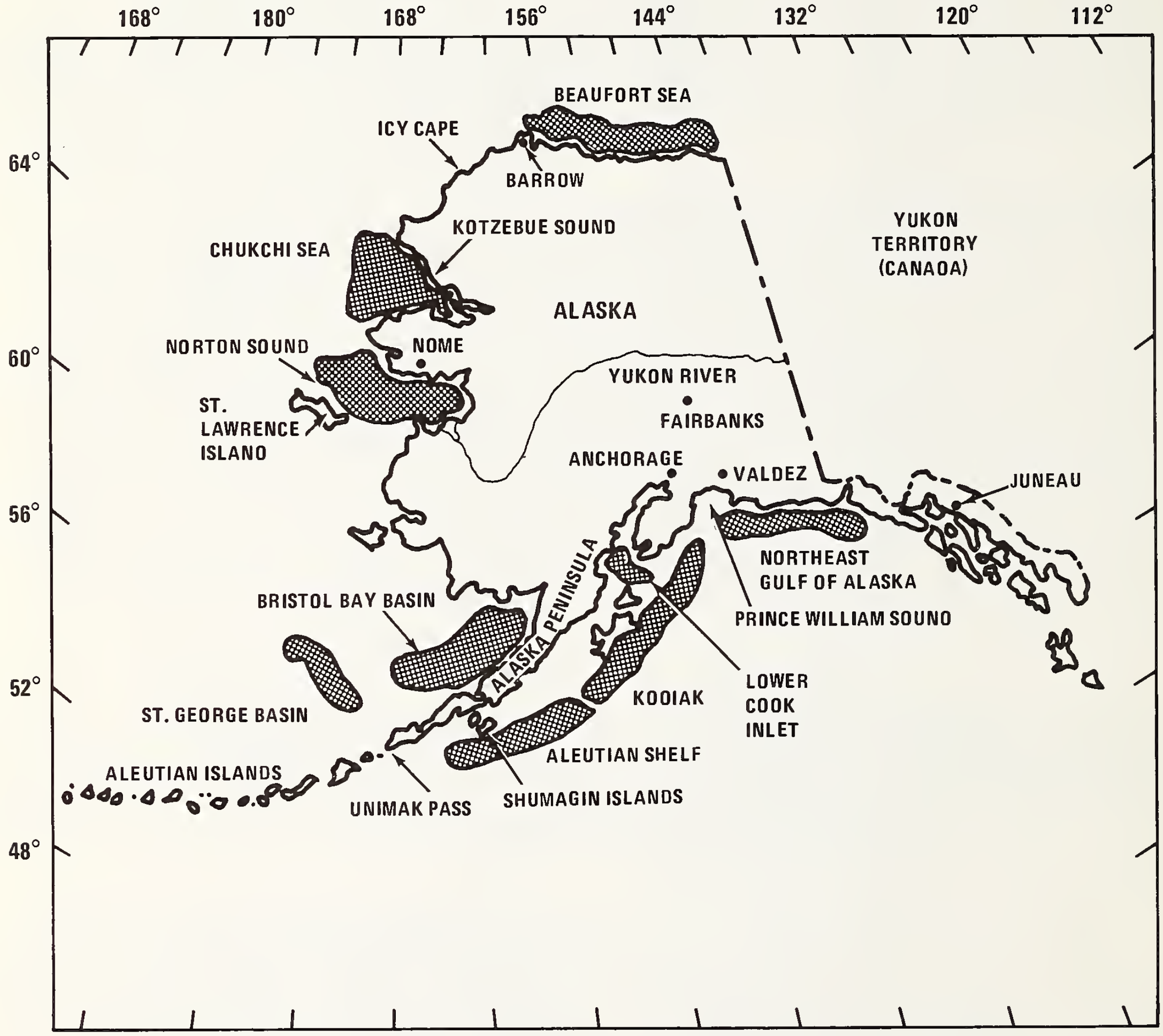

FIGURE 4-2. ALASKA OUTER CONTINENTAL SHELF LEASE AREAS (AS OF FY 1976)

management problems associated with these efforts form a seventh category for investigation.

Studies of natural hazards affecting lease development have been given priority. As a first step, five areas were identified that the NOAA research effort must address to get the information needed for BLM's program.

- What is the existing distribution, and what are the associated concentrations of potential contaminants concomitant with petroleum development?

- What are the nature and magnitude of contaminants and environmental disturbances that may be assumed to accompany petroleum exploration and development?

- What hazards does the environment pose to petroleum exploration and development?

- How are contaminant discharges moved through the environment and altered by biological, chemical, and physical processes?

- What biological populations and ecological systems are most subject to impact from petroleum exploration and development?

LEASE AREAS

In FY 76, nine potential areas for oil and gas development were identified on the outer continental shelf adjacent to Alaska (fig. 4-2). Each presents a unique set of environmental values: some, for example, encompass the sole nesting or living areas for various species of wildlife, while others are important fishing areas. Environmental hazards are also prevalent and varied, and include: frequent and violent storms, earthquakes, and moving sea ice with keels that plow the ocean floor sediments. OCSEAP research is assembling a comprehensive review of both the values and the hazards of this frontier region, and the ways in which they would affect or be affected by development of offshore oil and gas resources. Some of the early results, as they became available between July 1975 and September 1976, and plans for the following years (which have since been modified in view of the changed leasing schedule) are summarized by lease area in the following:

Northeast Gulf of Alaska

Frequent storms, with sea heights up to 9 m, producing heavy icing on ships and aircraft are common in this area, as are icebergs calved from coastal and fiord glaciers. Living marine resources are plentiful (see Part III, Overfishing, of this report), and seabirds abound. The Copper River delta is the nesting ground for the entire world population of dusky Canada geese. Large parts of the Gulf of Alaska, and especially such areas as Prince William Sound, are important fish spawning grounds.

The present understanding of physical oceanographic features was gained through evaluation of historical data, as well as from OCSEAP investigations. One of these studies of phytoplankton and primary productivity produced the startling result that phaeopigment/chlorophyll ratios were highest at the study site closest to the present petroleum-producing region (in State waters) in northern Cook Inlet. These large ratios are thought to be an effect of pollutants associated with this activity.

Research results in FY 76 on the thermohaline properties of the Gulf (the temperature-salinity structure of the waters) resulted in identification of the Alaska Stream (a northwest-flowing longshore current) as the principal influence on the general circulation of the area. Regions between Yakutat Bay and Middleton Island where the flow exhibits distinctive characteristics -- for example, the gyre behind Kayak Island -- have been described. Modeling studies and Lagrangian drift (current) studies show a high probability that surface materials released in the base area will go ashore west of the release point at Cape Suckling on Kayak Island in about five days, or will be held in the gyre between Kayak and Hinchinbrook Islands and ultimately beach near the entrance to Prince William Sound in about 10 to 40 days.

A number of other studies remain to be done in FY 78 (fig. 4-3). A detailed description is still needed of the circulation between the inner edge of the Alaska Stream and the coast, in the region from Icy Bay west to the entrance of Prince William Sound. Special emphasis should be placed on the relationship of nearshore circulation and local "katabatic" winds and other meteorologic conditions. ("Katabatic" winds are also known as gravity

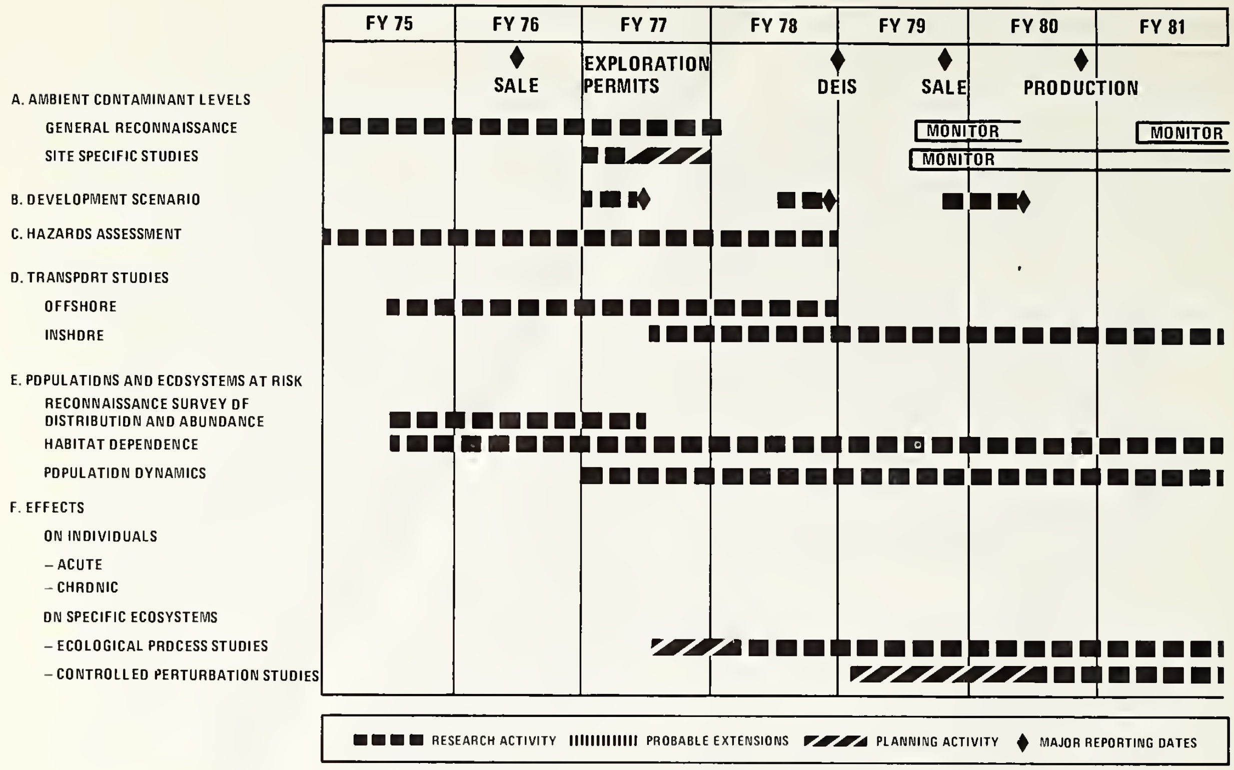

FIGURE 4-3. STUDY SEQUENCE – NORTHEAST GULF OF ALASKA LEASE AREA (FY 76)

drainage winds; as air cools over high ground, it drains down the hill.) Since flow from the Gulf base area apparently enters Prince William Sound, a detailed study is needed of the water mass through the entrance to the Sound to estimate residence time, and rate and level of buildup, of pollutants from the northeast Gulf lease area.

Lower Cook Inlet

Cook Inlet is a large shallow tidal estuary off the Gulf of Alaska, averaging 60 m deep. Rivers add vast quantities of glacial sediment to Inlet waters, particularly in summer. Lower Cook Inlet is a high-velocity channel containing turbid water that is well mixed vertically (the turbidity limits biological productivity), with a maximum current velocity of 6.5 kn.

Earthquakes pose a substantial hazard within the proposed Cook Inlet lease area, but not enough is known about the distribution of active surface faulting and the distribution and geotechnical properties of the Inlet's bottom sediments to permit adequate prediction of hazards. The maximum tectonic displacements recorded during the 1964 Alaska earthquake (maximum uplift, 15 m; maximum subsidence, 2.5 m; maximum horizontal movement on land, 19.5 m) should be considered carefully when design criteria are established for Cook Inlet development. In addition, five active volcanos lie along the western shore of the Inlet. Of these, probably the greatest threat comes from Augustine, which erupted in 1883. The volcano is now building a lava dome within the 1883 crater, and a future eruption is most likely.

Ice usually forms in Upper Cook Inlet early in December, and breakup is generally complete by late April. At present, no data are available concerning the possible effects of ice, or of water flow patterns on transport and trajectories of spilled contaminants. A simulation model of probable spill trajectories from 12 potential lease sites (selected by the OCS office of BLM, Anchorage) was prepared in 1976 studies. However, results should be interpreted with caution, since they are not necessarily conservative, upper-bound estimates of risk; actual risks may be found to be substantially greater.

Preliminary investigations of the use of light molecular weight hydrocarbons as indicators of petroleum contamination were made in April. Methane concentrations in the near-surface and near-bottom waters were always above atmospheric saturation. The highest concentrations noted were near the Forelands and may result from natural petroleum seeps and/or nearby petroleum development. Water from Kamishak and Kachemak Bays also contained methane levels markedly higher than atmospheric equilibrium, but near-bottom concentrations do not indicate a bottom source, implying that the methane may be originating from a surface source. Site-specific studies will be made in the summer of 1977 in the upper Cook Inlet region of producing gas and oil wells to assess the validity of hydrocarbon tracers under extreme mixing conditions (fig. 4-4).

The relative significance of Inlet wetlands remains to be determined. A tentative food web has been constructed for offshore benthos. As with littoral zone fauna, many of these species depend heavily on organic detritus for food, and possibly the meiofauna (small animals that live between sand grains). With the exception of commercially important species, little is known about benthic invertebrates in the Inlet.

Investigators have identified 22 species of seabirds and waterfowl in the lower Inlet area. Preliminary summaries of seasonal usage by and food habits of principal bird species have been prepared, and principal potential hazards of petroleum development to marine birds have been initially identified.

Western Gulf of Alaska - Kodiak

Near Kodiak Island in the western Gulf, the continental shelf extends 240 km offshore. This area, too, is subject to frequent and severe earthquakes. The waters here are among the most productive in the North Pacific. Major fisheries include dungeness, king, and tanner crabs, shrimp, and a variety of bottomfish such as pollock, and the region is an important feeding ground for maturing salmon.

In the western Gulf, the data base still is inadequate for a coherent picture of mesoscale circulation. Sample current measurements at two locations in the northeastern part of the Kodiak lease area (in September 1975 and April 1976) revealed important features within a part of the

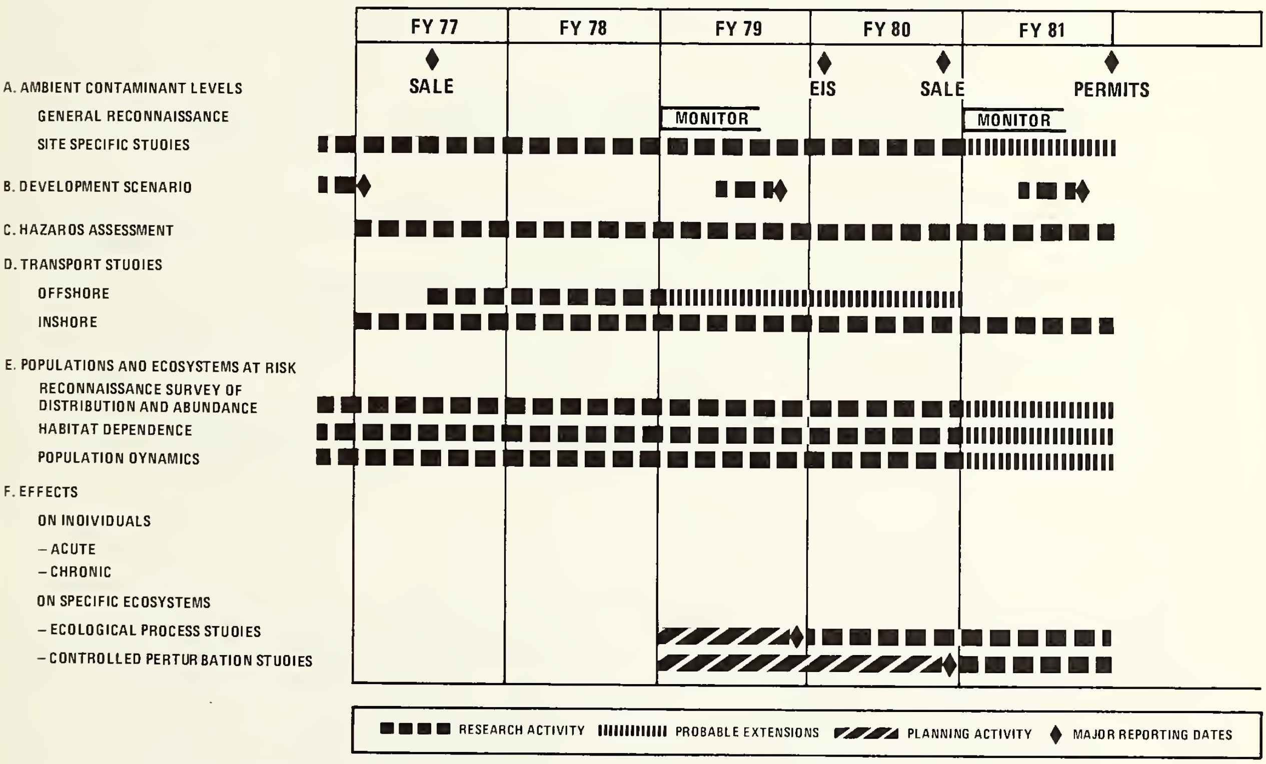

FIGURE 4-4. STUDY SEQUENCE – LOWER COOK INLET LEASE AREA (FY 76)

lease area. Additional current meters were deployed around Kodiak Island during October 1976 - the first systematic measurement program in that area. These arrays were recovered in March 1977, and the data are being analyzed. Additional work is needed to determine how the flow from the northeast Gulf is partitioned among the areas of the Kodiak shelf, Cook Inlet, and Shelikof Strait. Early evidence suggests that water residence times on the shelf may be relatively long, compared with flow toward the southwest farther offshore. This, in turn, may help to explain the very high biological productivity of Kodiak shelf waters. Such studies are a part of the OCSEAP sequence in this area (fig. 4-5).

Seismic studies in the Aleutian area, closely coordinated with those near Kodiak, are part of a combined Energy Research and Development Administration/OCSEAP project to define the seismotectonics of the area. A primary goal is to investigate large-scale, slow crustal movements within the Shumagin seismic gap shown to exist by plots of epicenter locations and aftershock zones between the Shumagin Islands and Kodiak Island. The region has been seismically quiet since the 1938 Shumagin Islands earthquake, but is believed to be an area of accumulating tectonic strain likely to be released in the not-too-distant future by a great earthquake or a series of major earthquakes, or both.

Limited studies of concentrations of hydrocarbons and metals were made on the Kodiak and Aleutian shelves during FY 76. Results indicate that concentrations along the Kodiak and Aleutian shelves may be as low as in other open-ocean uncontaminated regions. Studies of petroleum in sediments from Alaska OCS areas also began in FY 76. However, the analytical chemistry associated with extraction of petroleum compounds from sediments is extremely difficult and is still being developed.

A preliminary list shows that 128 species of anadromous, demersal, and pelagic fish have been reported in the western Gulf, mostly from over the shelf and slope areas. Both the more mobile (salmonids) and the benthic species (pleuronectids) appear to spend some segment of their life cycle in the surface or nearshore waters. Therefore, any perturbations of the OCS waters may affect these species, some of

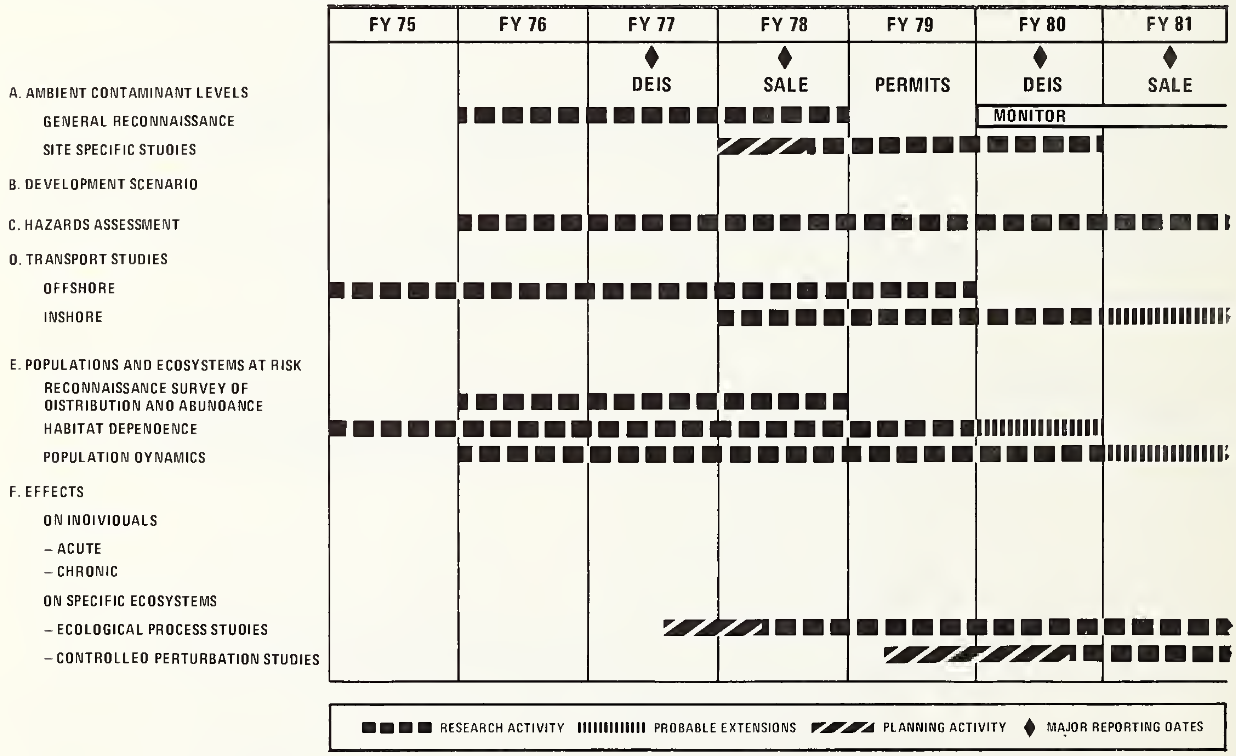

FIGURE 4-5. STUDY SEQUENCE – WESTERN GULF OF ALASKA, KODIAK LEASE AREA (FY 76)

which are essential to commercial fisheries and an expanding sport fishery.

The western Gulf area is considered the center of the world population of Steller sea lions. Several hauling areas (onshore resting and breeding grounds) previously unreported in the literature have been located by OCSEAP investigators, on the north end of the Kodiak Archipelago. Tugidak Island, south of Kodiak, has been clearly identified as the focus for the largest concentration of harbor seals, with populations reportedly exceeding 10,000 animals at certain times. Nearly all of the North American population of gray whales apparently passes through Unimak Pass to and from summering grounds farther north.

Aleutian Shelf

In winter, intense storms move eastward across the Aleutian Shelf region into the northern Gulf of Alaska, generating 3.6 m waves every winter, with 9.0 m waves occasionally reported. Rainfall is considerable: the annual amount measured at Chignik averages 323 cm. The existing physical oceanographic data base in the Kodiak lease area is sparse at present, and that in the Aleutian area is even more meager. So far, only two current meter moorings have collected data in the region -- one southeast of Unimak Pass and the other farther north near the Semidi Islands. The Alaska Peninsula shelf between these two locations -- essentially the entire lease area -- is entirely devoid of current meter measurements. A major OCSEAP objective for FY 78 will be to obtain current observations along the Alaska Peninsula shelf so as to form a preliminary descriptive picture of Aleutian shelf circulation (fig. 4-6).

An estimate of repeat times for earthquakes within the Shumagin seismic gap suggests that a great earthquake (magnitude > 7.9 on the modified Mercalli scale) will occur between 1964 and 2288, most probably between 1998 and 2025. Hence, it is likely that a great earthquake would occur during petroleum production within the Aleutian lease area.

The Department of the Interior (1975) estimates that a minimum of 3 million birds breed in this general area, and it has been proposed for National Wildlife Refuge status.

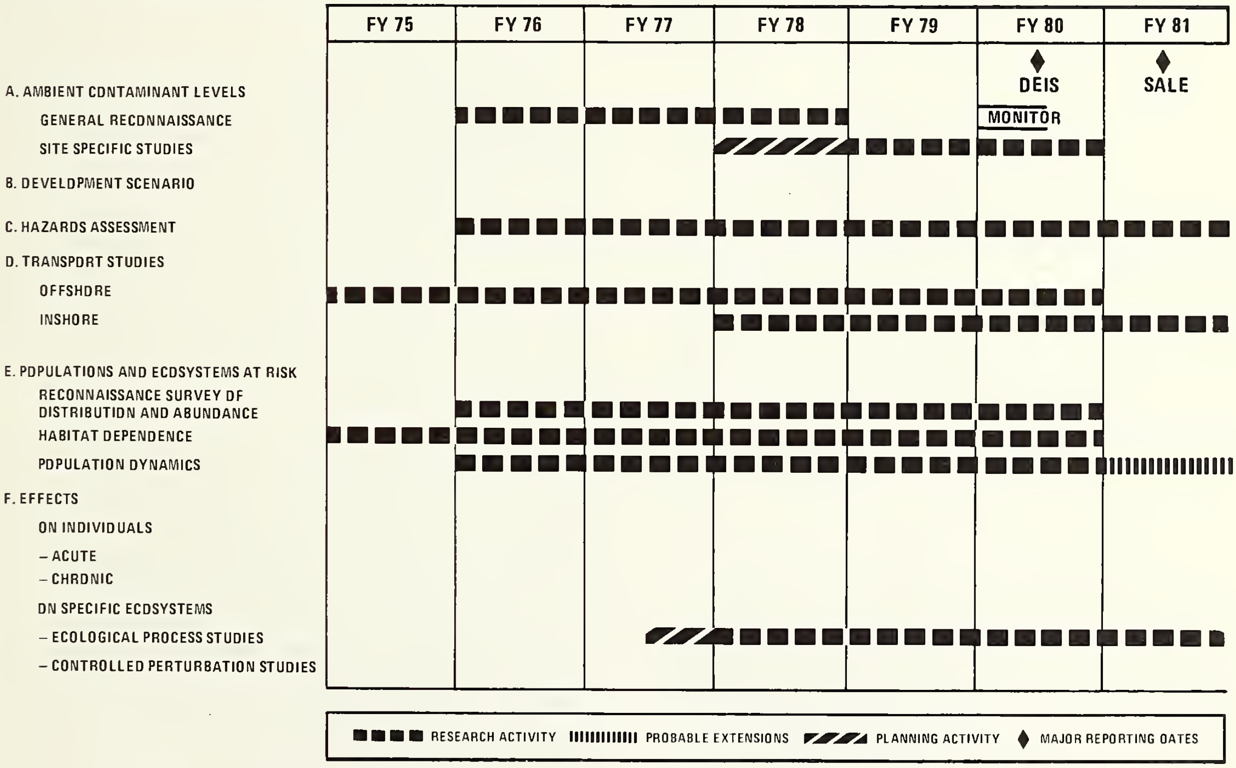

FIGURE 4-6. STUDY SEQUENCE – ALEUTIAN SHELF LEASE AREA (FY 76)

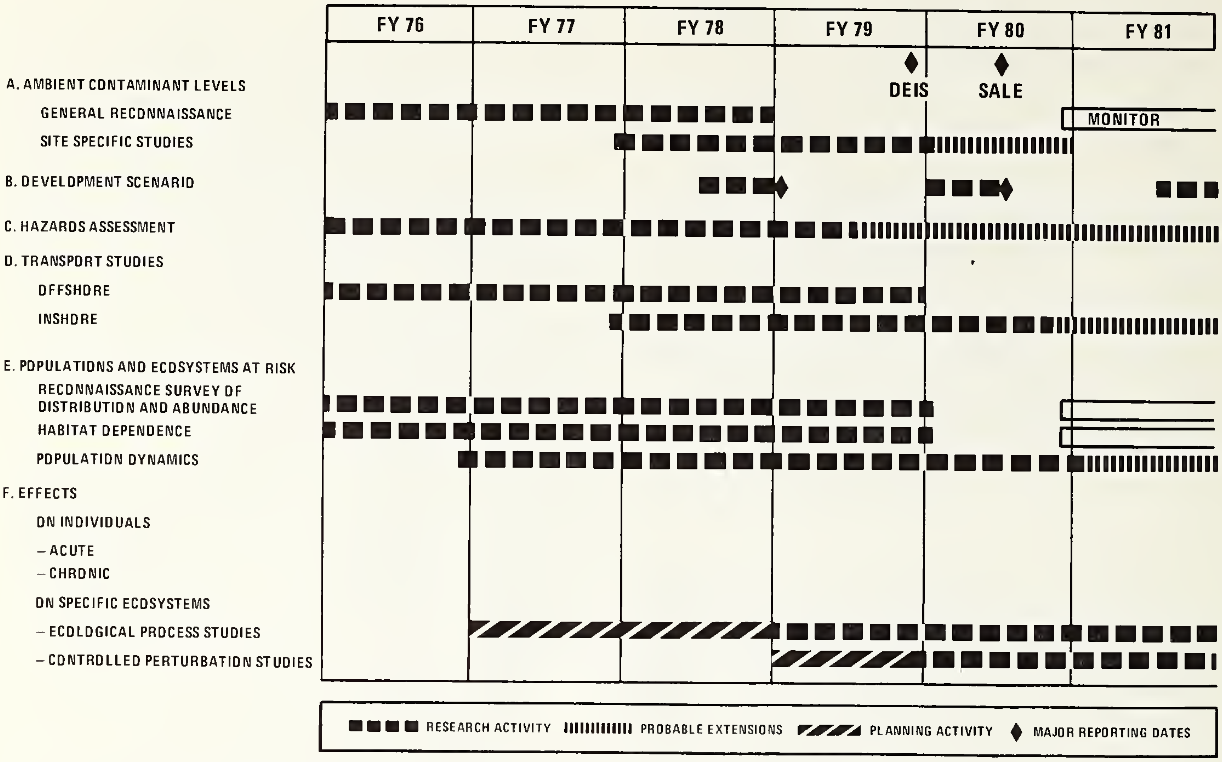

FIGURE 4-7. STUDY SEQUENCE – BERING SEA, ST. GEORGE BASIN LEASE AREA (FY 76)

Bering Sea - St. George Basin

The Bering Sea covers about 2.3 million km^2. It is considered an extension of the Pacific Ocean, but is neither truly arctic nor temperate, and is characterized by dramatic changes in water properties when ice covers nearly half its surface in winter, then melts away completely in summer. The continental shelf, accounting for 44 percent of the total Bering Sea area, is one of the largest in the world, extending more than 600 km offshore in the northeast sector. It is a flat, gently sloping, submerged plain with an average water depth of less than 100 m.

Despite what appears to be a harsh climate for phytoplankton growth, this shelf region supports phenomenally high primary production. Even the undersurface of the ice is highly productive during some periods of the year. Large stocks of cod, herring, Pacific ocean perch, pollock, sablefish, and several species of flatfish support a lucrative commercial fishery. Five species of Pacific salmon migrate through this area. Offshore, marine mammals are not as abundant as in coastal areas, but the entire North American population of northern fur seals breeds on the Pribilof Islands.

Sets of new data, principally on hydrography and currents, have been obtained through OCSEAP (fig. 4-7). Preliminary analysis of data obtained in March 1976 shows that there is a strong inflow of water onto the shelf, in the vicinity of the Bering Canyon. The inflowing water mass divides, with the western portion flowing over the shelf break and turning to the northwest, and the eastern portion ultimately flowing into Bristol Bay, moving parallel to the Alaska Peninsula. In general, flow is dominated by tidal activity.

New data have helped identify and explain many of the special oceanographic features of the St. George region. It is becoming clear that circulation of the adjacent deep basin affects shelf waters strongly. Mutually supportive modeling studies and field programs are aimed at study of the dynamic processes in this area. The model results also can be used to study transport and dispersion of larvae of commercially important fish as well as any discharged contaminants.

Because of the paucity of data, annual primary productivity estimates are not available. In 1976 new data were reported on chlorophyll-a concentration and species composition and distribution of phytoplankton with reference to the ice edge. As a result of information collected and analyzed under OCSEAP, distribution patterns of major taxa and communities are being established. However, knowledge of biomass distribution, trophic relations, and productivity still is limited.

A sound knowledge of the distribution of major organisms, their migratory pathways, habitat dependence, food relations, and potential susceptibility to impact is a prerequisite for a thorough understanding of the eastern Bering Sea ecosystem. Quantitative representation of this knowledge will also provide the basis from which to discern the effects of man (fishing, industrial development) or anomalous environmental conditions. OCSEAP projects currently underway are beginning to provide the data and interpretations needed to achieve this.

Bering Sea - Bristol Bay

Bristol Bay is a large, comparatively shallow bay with a surface area of more than 150,000 km^2 and an average depth of 40 m. It is one of the most important salmon fishing grounds in the world and is extensively used for navigation between area villages. The Bay may be divided into a predominantly estuarine inner area and an outer bay with a more oceanic character. Primary productivity is generally higher in the lagoons and coastal basins than in adjacent offshore waters. Development of diverse intertidal communities is hampered by extreme tidal ranges that expose vast expanses of shoreline twice daily, and by variable salinities, irregular currents, and winter ice that scours the coast.

Some of the largest seabird rookeries in the world are in Bristol Bay. The entire Pacific population of black brant gathers before fall migration in this area, feeding almost exclusively in the coastal eelgrass lagoons, accompanied by hundreds of thousands of ducks, geese, and shorebirds. Marine mammals are diverse and numerous along the coast: baleen whales migrate here in summer; killer whales and beluga are common; Steller sea lions are found along the rocky coast, while harbor seals prefer gentle slopes and sandy beaches; sea otters are common; and the Walrus Islands in summer have several hundred bull walrus.

OCSEAP-sponsored research has resulted in useful sets of new data, principally on the hydrography and current regimes (fig. 4-8). The data have helped identify and explain many of the special local oceanographic features. It appears, for example, that there is a considerable diversity of water characteristics over the continental shelf.

Bristol Bay's Alaska Peninsula coastal zone includes 1,400 km of beaches and 129,000 ha of associated mudflat and onshore habitats heavily used by gulls, waterfowl, and shorebirds, particularly during spring and fall migration. Unimak Pass is a gateway through which millions of seabirds, migrating into and out of Bristol Bay, are funneled at rates of thousands of birds per hour. Additional data on population dynamics, feeding rates, food selectivity, and growth are still needed for nearly all important taxa.

Northern Bering Sea - Norton Sound

The northern Bering Sea is heavily influenced by seasonal ice cover much of the year. The Yukon-Kuskokwim River delta is the major river delta system of Alaska, composed largely of glacial sediments and characterized by extensive meandering river channels and marshy ponds. Bering Strait, 70 km wide between Alaska and Siberia, is the gateway through which Bering Sea water drifts northward into the Chukchi Sea and the Arctic Ocean.

The presence or absence of ice profoundly affects the movement and behavior of fish, birds, and marine mammals in this area. Many species congregate near the edge of the pack ice and move in response to the ice. Fish are generally small and sparsely distributed, but five species of Pacific salmon inhabit this area, and arctic char are abundant and spawn in many of the rivers. In addition, there are walrus, four species of seals, and 10 species of whales in the region. Polar bears sometimes pass southward through Bering Strait, but seldom as far as St. Lawrence Island.

The Yukon River provides 90 percent of the sediment introduced into the Bering Sea, as well as freshwater input of more than 160 km^3/year. Spring tides and storm surges can result in reversal of flow, driving the relatively fresh water immediately offshore back up the river and causing extensive flooding of the delta. The area is characterized by discontinuous permafrost, faults, frequent major coastal storms, and complex hydrological features, all of which will

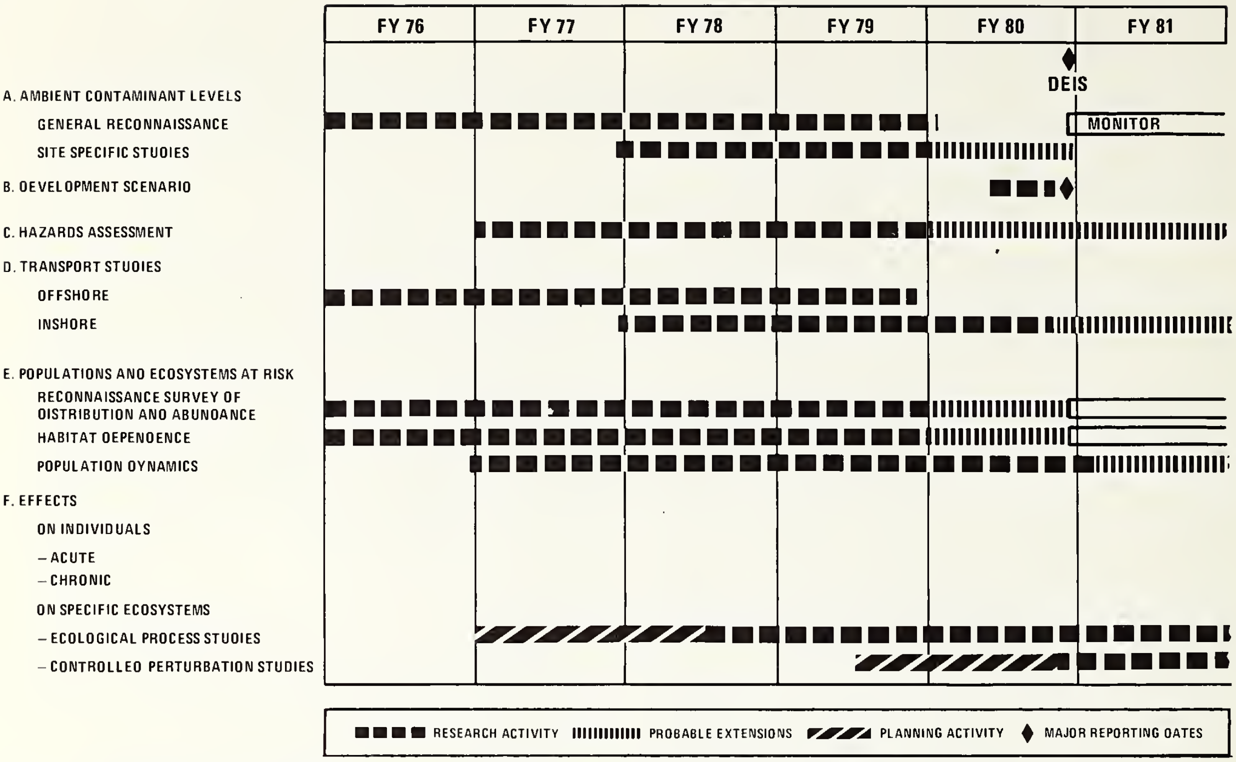

FIGURE 4-8. STUDY SEQUENCE – BERING SEA, OUTER BRISTOL BAY LEASE AREA (FY 76)

make planning and siting for development extremely difficult.

The most detailed current and hydrographic data yet obtained from Norton Sound were collected by an OCSEAP research unit during the autumn of 1976. Yukon River discharge is incorporated mainly into the northerly offshore Bering Sea current that crosses the mouth of Norton Sound. However, distributions of salinity and suspended sediment indicate that part of the discharge moves eastward into Norton Sound along its southern shore. (Since such freshwater drainage drives nearshore circulation throughout all the lease areas, a study of Alaska river discharges has been undertaken and will be completed during FY 77.) Upon recovery in October 1977 of moored current meter arrays, one year of continuous records will have been obtained from this region; results of analyses of the data are not expected until early 1978. Tidal current information from shipboard measurements during 1976 should be available in the FY 77 annual reports (fig. 4-9).

A large-scale hydrocarbon seep was discovered during FY 76. An unusual accumulation of dissolved hydrocarbons (C_2 -- C_4) was found in the water about 40 km south of Nome. Concentrations of ethane and propane reached maximum values of 9.6 and 3.3 nℓ/ℓ (at standard temperature and pressure -- STP) at the locus of the seep, more than a factor of 10 above ambient levels observed toward the east and south. The localized source and characteristic plume structure strongly suggest a natural gas seep, possibly associated with petroleum. A detailed chemical and biological program will be established to examine the environmental consequences of a natural seep into the shallow waters of an Arctic basin that is covered by ice approximately eight months a year. If the seep is composed of heavier fractions of petroleum, it can serve as a natural laboratory to study a wide range of questions surrounding the fate of petroleum in a natural, pristine environment.

An intensive survey will be made to determine whether seep-derived hydrocarbons are present in organisms, sediments, and waters. The first step will be to identify all the hydrocarbons coming from the seep. If heavier fractions are found, a detailed investigation will be made of hydrocarbon distribution in the local biota and sediments. How the large amount of suspended

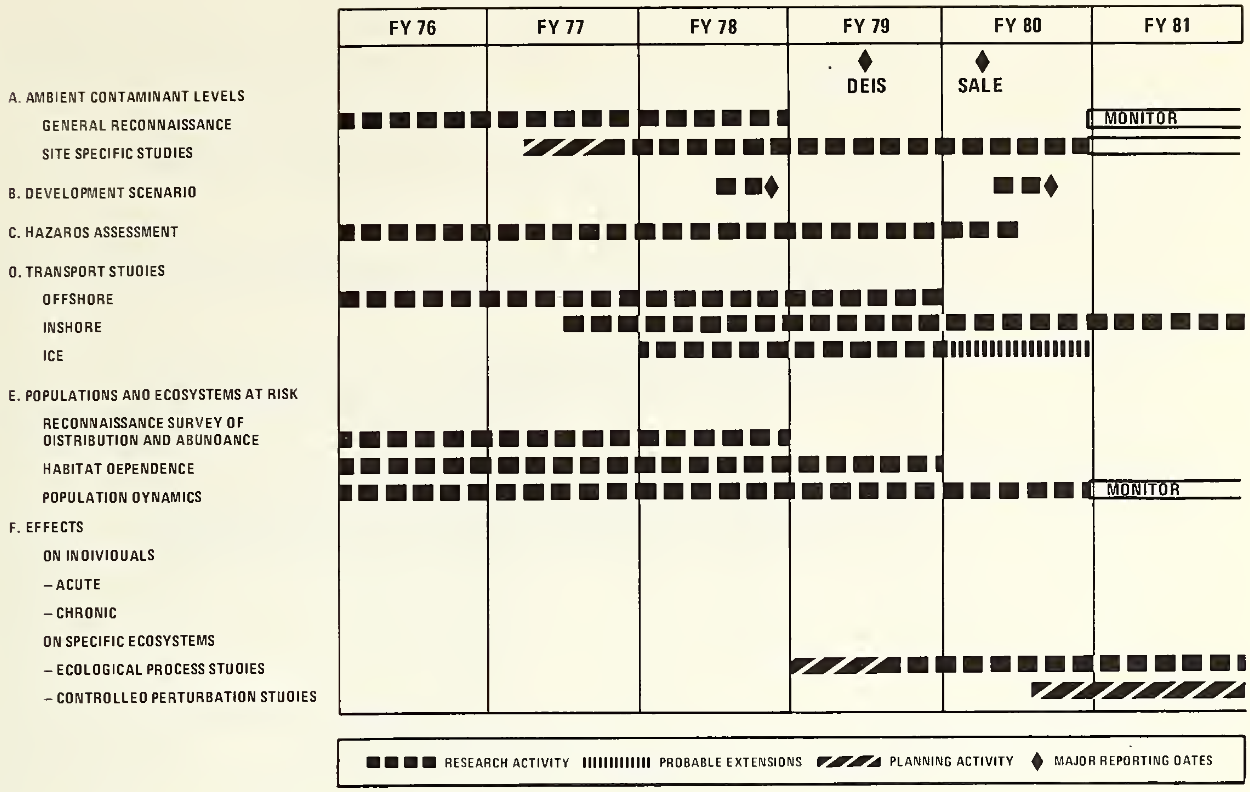

FIGURE 4-9. STUDY SEQUENCE – NORTHERN BERING SEA, NORTON SOUND LEASE AREA (FY 76)

sediments in Norton Sound affect the transport of seep hydrocarbons also will be assessed. Finally, if a petroleum seep of significant magnitude is identified, studies of how it affects composition, diversity, and benthic habitats of species should be carried out.

Chukchi Sea

The Chukchi Sea averages 45 m to 55 m in depth; its bottom is a flat, featureless plain connecting the Alaska landmass to the Siberia landmass. The surface of this shelf is affected in most areas by dragging sea ice chunks and keels of pressure ridges, especially nearshore. The shelf is probably underlain by continuous thick permafrost below an active layer as deep as 3 m. The low-lying Alaska coast of the Chukchi Sea is a somewhat broken, beadlike, series of lagoons along much of the coastline from Cape Prince of Wales to Point Barrow.

Ocean currents in the Chukchi Sea have a broad counterclockwise circulation. Annual sea ice coverage varies greatly, and is not a solid mass: polynyas and leads are present in both the polar and winter pack, and in summer open water becomes extensive along the entire coast. Normally, polar ice varies from about 4 m thick at the end of winter to 1.8 m in summer. Pressure ice may be lifted 12 m or more along the coast by onshore winds. Beneath the ice, pressure ridge keels may hang 18 to 30 m deep.

Although the Chukchi Sea is better understood than the even-more-remote Beaufort Sea, large gaps remain, particularly when it comes to assessing the likely impacts of and hazards to offshore development. For this effort, now underway under OCSEAP (fig. 4-10), little background information is available. Sea ice conditions, for example, are similar to those in the Beaufort Sea and may preclude leasing for an indefinite period. Properties and processes of subsea permafrost are generally known, but an understanding of its presence in this region is still lacking.

In the Chukchi Sea, with the possible exception of inner Kotzebue Sound, the ocean circulation is adequately known or will be known at the end of FY 78. A large remaining gap in the understanding of ocean transport is the lack of knowledge of nearshore

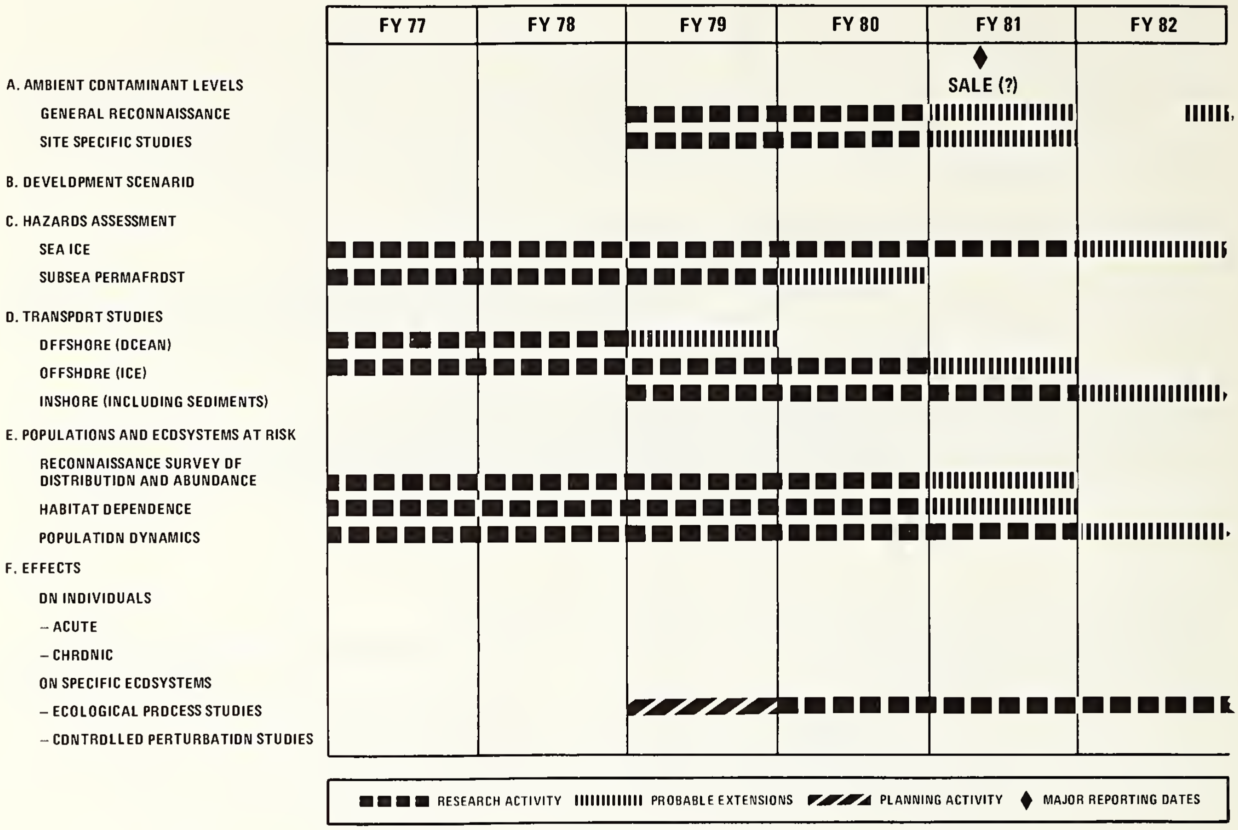

FIGURE 4-10. STUDY SEQUENCE – CHUKCHI SEA LEASE AREA (FY 76)

circulation. For most of the year, ice covers the area. Any pollutants spilled at the surface will be transported by the ice (which is primarily wind-driven) and not by ocean currents. Movement of ice over the Chukchi Sea shelf varies greatly from year to year, but is not well understood. In particular, large ice outbreaks to the Bering Sea occur early in spring in some years, but not in others.

OCSEAP is making a large number of studies of the effects of petroleum on various biota; however, none specifically concerns Chukchi or Beaufort Sea species. Much past information about seals and walrus was acquired through excellent cooperation with hunters at various coastal villages, and this cooperation continues under OCSEAP.

Beaufort Sea

The Beaufort Sea has a very narrow continental shelf extending 48 km to 96 km off the northern coast of Alaska, with depths less than 200 m. Some evidence suggests that offshore barrier islands, the distinctive feature of this coast, are tundra remnants. Surface currents flow westward between MacKenzie Bay and Point Barrow. However, local winds may reverse this drift and set the current easterly in nearshore reaches. The wind has unusually great impact; it affects water levels more than tides do, and moves the ice pack either shoreward or offshore. Storms are frequent, particularly in summer, occasionally generating storm surges that strongly impact the coast. Ice cover is essentially complete in winter except for leads and polynyas.

The coast is subject to polar ice action throughout the Beaufort Sea region. In some cases offshore barrier islands and shorefast ice protect the mainland, but they may be overridden by the polar pack in years of severe stress. Large chunks of floating sea ice, occasional pieces of broken ice islands, and deep keels of pressure ridges become grounded in the shelf sediments and form deep gouges in the sea floor. Freezeup and breakup dates are variable and unpredictable. At Point Barrow, freezeup may occur anytime between early September and late November; breakup varies from mid-June to late August.

The Beaufort Sea is perhaps the least scientifically known of all the Alaska lease areas. The severe winter climate, complete darkness with temperatures as low as -50°C, the presence of sea ice for 9 to 10 months every year, and the remoteness and inaccessibility of the area have prevented a systematic assessment of the offshore environment in the past. OCSEAP efforts have had some successes so far, but substantial gaps remain in the understanding of biological and physical processes. (An OCSEAP synthesis of all available information took place at Barrow in February 1977 with a draft report available by the end of May.) Limited information available now seems to indicate that levels of hydrocarbons and heavy metals are very low and that the environment is quite "clean." Plans now include studies to bridge the gaps that have been identified (fig. 4-11).

Prior to OCSEAP efforts nothing was known about the ocean circulation and hydrographic regime under the ice on the Beaufort Sea continental shelf, but this essential information should be available at the end of FY 78. A large remaining gap in understanding ocean transport is knowledge of nearshore circulation, particularly in the lagoon systems and between the barrier islands. The latter problem is also crucial to understanding the sediment regime and transport along the coast, and the stability of natural and artificial islands and causeways.

The behavior of oil in ice is not well understood. For example, there still remain unanswered questions about the mechanisms of "lead-pumping" -- the rapid spreading of oil by repeated opening and closing of leads in the ice. Studies of the processes of weathering and biodegradation of oil under the ice (the rates are much lower than in the open ocean) are to begin in FY 78.

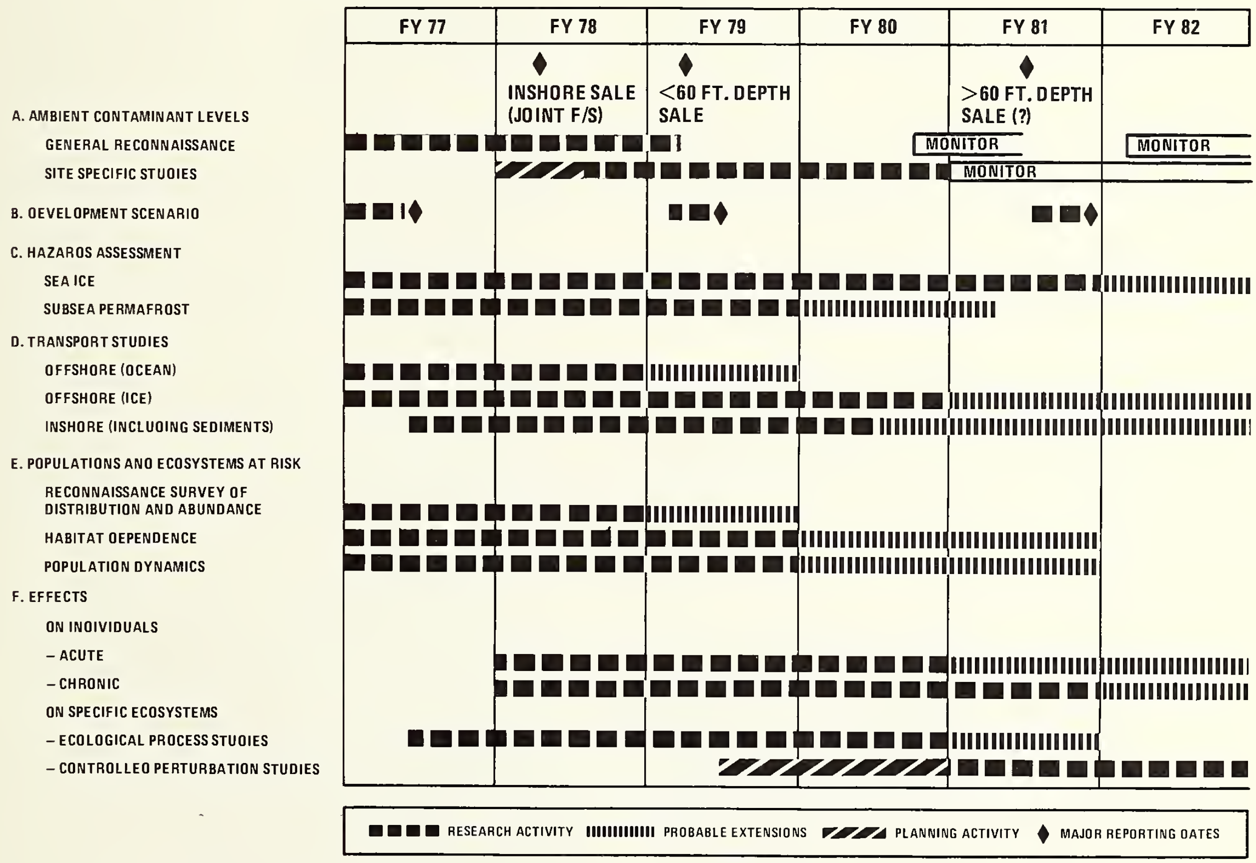

FIGURE 4-11. STUDY SEQUENCE – BEAUFORT SEA LEASE AREA (FY 76)

Although OCSEAP biological survey efforts should be concluded within a year or so, the remaining gaps may be difficult to fill. These involve: winter fish populations in nearshore areas; offshore fish, both winter and summer (the limited cruises on the USCG icebreakers, the only ships available for the purpose, do not allow adequate trawling efforts); summer distribution and migration of marine mammals (particularly bowhead whales and beluga); benthos in the region between the barrier islands and water depths of 20 m (the closest the icebreakers can come to land); and microbiological populations. Life history and bioassay studies of polar cod and euphausiids are particularly needed, as they are important bird and mammal prey.

APPENDIX A
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APPENDIX B

MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT OF 1972

TITLE II

TITLE II—COMPREHENSIVE RESEARCH ON OCEAN DUMPING

Report to Congress.

*

SEC. 201. The Secretary of Commerce, in coordination with the Secretary of the Department in which the Coast Guard is operating and with the Administrator shall, within six months of the enactment of this Act, initiate a comprehensive and continuing program of monitoring and research regarding the effects of the dumping of material into ocean waters or other coastal waters where the tide ebbs and flows or into the Great Lakes or their connecting waters and shall report from time to time, not less frequently than annually, his findings (including an evaluation of the short-term ecological effects and the social and economic factors involved) to the Congress.

SEC. 202. (a) The Secretary of Commerce, in consultation with other appropriate Federal departments, agencies, and instrumentalities shall, within six months of the enactment of this Act, initiate a comprehensive and continuing program of research with respect to the possible long-range effects of pollution, overfishing, and man-induced changes of ocean ecosystems. In carrying out such research, the Secretary of Commerce shall take into account such factors as existing and proposed international policies affecting oceanic problems, economic considerations involved in both the protection and the use of the oceans, possible alternatives to existing programs, and ways in which the health of the oceans may best be preserved for the benefit of succeeding generations of mankind.

(b) In carrying out his responsibilities under this section, the Secretary of Commerce, under the foreign policy guidance of the President and pursuant to international agreements and treaties made by the President with the advice and consent of the Senate, may act alone or in conjunction with any other nation or group of nations, and shall make known the results of his activities by such channels of communication as may appear appropriate.

Annual report to Congress.

**

(c) In January of each year, the Secretary of Commerce shall report to the Congress on the results of activities undertaken by him pursuant to this section during the previous fiscal year.

(d) Each department, agency, and independent instrumentality of the Federal Government is authorized and directed to cooperate with the Secretary of Commerce in carrying out the purposes of this section and, to the extent permitted by law, to furnish such information as may be requested.

Inter-agency agreements.

(e) The Secretary of Commerce, in carrying out his responsibilities under this section, shall, to the extent feasible utilize the personnel, services, and facilities of other Federal departments, agencies, and instrumentalities (including those of the Coast Guard for monitoring purposes), and is authorized to enter into appropriate inter-agency agreements to accomplish this action.

Federal-State cooperation.

SEC. 203. The Secretary of Commerce shall conduct and encourage, cooperate with, and render financial and other assistance to appropriate public (whether Federal, State, interstate, or local) authorities, agencies, and institutions, private agencies and institutions, and individuals in the conduct of, and to promote the coordination of, research, investigations, experiments, training, demonstrations, surveys, and studies for the purpose of determining means of minimizing or ending all dumping of materials within five years of the effective date of this Act.

Appropriation.

SEC. 204. There are authorized to be appropriated for the first fiscal year after this Act is enacted and for the next two fiscal years thereafter such sums as may be necessary to carry out this title, but the sums appropriated for any such fiscal year may not exceed $6,000,000.

**

*Sec. 3(a) of the Act reads: "Administrator" means the Administrator of the Environmental Protection Agency.

**P.L. 94-62, Section 2, amended Section 202(c) of the 1972 Act by striking "January" and inserting "March". Section 3 of P.L. 94-62 amended Section 204 of the 1972 Act by authorizing $1,500,000 for the transition period (July 1 through September 30, 1976). P.L. 94-326, Section 3, amends Section 204 of the 1972 Act by authorizing $5,600,000 for fiscal year 1977.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1977—261-238/409

NOAA--S/T 77-2839